ENGINEERING

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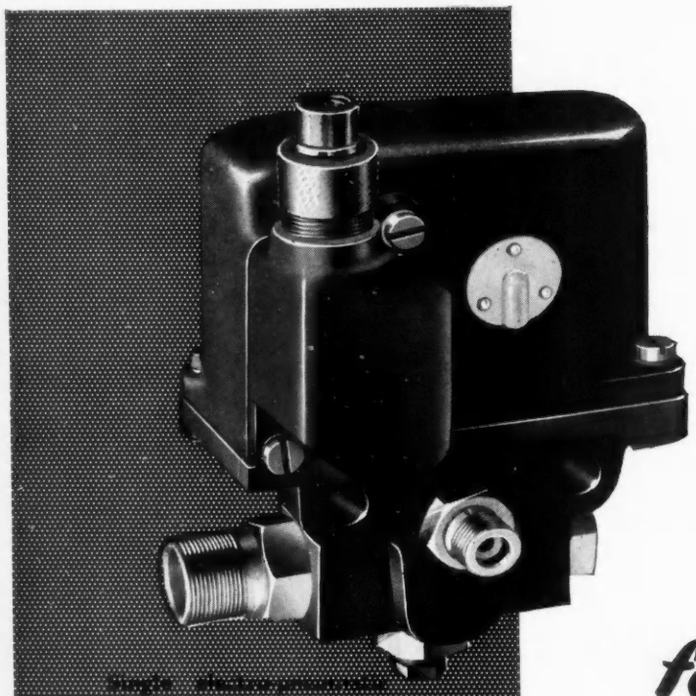

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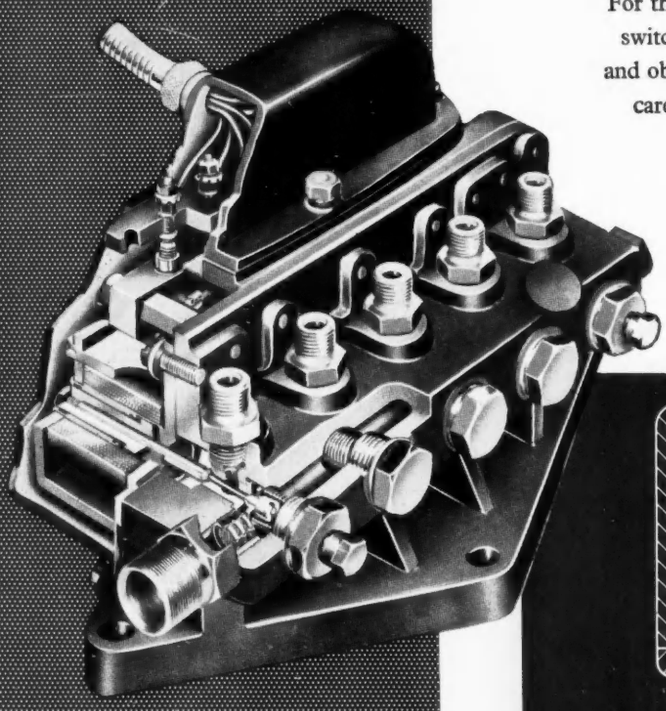

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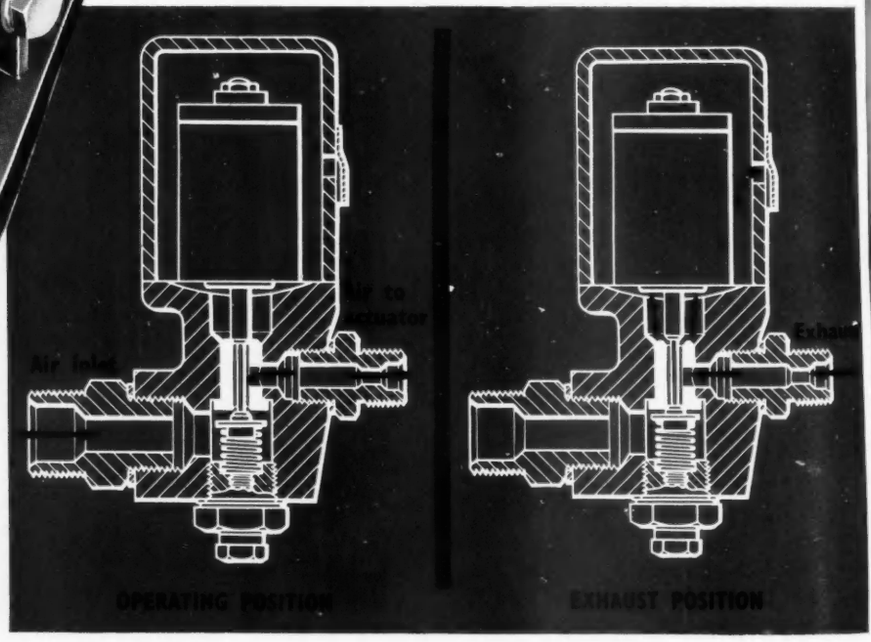

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ENGINEERING

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Contents

193 **Leading Article**
Twenty Thousand Leagues

194 **Plain Words**

195 **Letters to the Editor**
Railway Accidents

200 **Automobile Engineering**
450 Plus—Problems of High Speed Cars: The New Bluebird Takes Shape

201 **Companies in the News**

202 **Atomic Review**
Contracting Parties

Special Articles

205 By Way of the North Pole: U.S.S. Nautilus
206 India's Iron and Steel Industry Grows

218 **New Books and Trade Publications**

219 **Book Reviews**
Prestressed Concrete: Theory and Practice
Prestressed Concrete: Theory and Design
Engineering Economics, Book 1

219 **On the Shelf**

224 **Engineering at Home**
Resilient Fan
Southampton Interview Studio
Radiant Heater
Chillerton Down

. . . . . .

194 **Management**
Weekly Survey
209 Companies in the Commonwealth: 1—Hawker Siddeley Group

196 **Plant and Equipment**
Cooled Mechanical Seal
Silicon Power Rectifier
Dual Pivot Loader
Small Pneumatic Vice
High Precision Lathe
Aluminium Platform Truck
Machine Vice
Magnetic Conveyors
Lightweight Signalling Lamp
Replica of Maudslay's Lathe
Grinding Small Radii
Torque Limit Pulley
Cutting Right and Left-Hand Threads
Aluminium Conductor Accessories

199 **The Human Element**

208 **Marketing**

210 **Production**
High Speed Beer Bottling
1,000 Hour Life for Civil Avons
Automatic Sawing of Boards and Plastics
Power Screwdriver

213 **Research and Development**
Non-Linear Vibrations in Mechanical Systems
Sense of Direction
Thermistored Crystal Oscillator
Strengthening the Links of Radio
Testing Helicopter Rotors

220 **Design**
Low Consumption Diesel Engine for Heavy Vehicles
Main-Line Diesel-Electric Locomotive
Re-designing Vehicles to Speed Materials Handling
Transistors for Fluorescent Lighting Supply
Transverse Propulsion for "Oriana"

223 **Metals and Materials**
Recovery of Sulphur from Coke-Oven Gas
Reducing Worm Holes in Welded Pipe Joints
More M.P.G.—by Castor Oil
Symposium on Rubber

Twenty Thousand Leagues

PART of an engineer's job is to predict. He must foresee how machines and their components will behave in even the most rigorous conditions, and make due provision for any faults that can conceivably occur. At one time his aptitude for clairvoyance depended entirely on his experience; his methods were empirical; and unless he tested components in circumstances identical with those in which they would be called upon to operate, they were prone to let him down. To-day, though basically the same, his approach has assimilated many of the abstract procedures developed by the scientist—procedures that permit extrapolation far beyond the test-bed, procedures as different from their predecessors as was the route to the Indies chosen by Columbus from the coast-clinging passage of Bartholomew Diaz. Although theoretical engineering has already a considerable history, its potential has seldom been more dramatically demonstrated than by another, more recent voyage, that of the Nautilus.

Last week when the White House announced that the nuclear-powered submarine Nautilus had surfaced near Greenland after passing under the Arctic ice cap—a voyage that must inevitably be compared with the astounding adventures of Jules Verne's fictional Nautilus—emphasis was rightly placed on the daring of the crew and the prospects they had revealed. President Eisenhower's citation, when the submarine's captain, Commander W. R. Anderson, was decorated for his achievement, included the following words. "Under his intrepid leadership, Nautilus pioneered a submerged sea lane between the eastern and western hemispheres. This points the way for further exploration and possible use of this route by nuclear powered cargo submarines as a new commercial seaway between the major oceans of the world." More generally, the voyage shows the value of seeking unusual applications for engineering that might in normal circumstances seem uneconomic. A journey of this kind could in the present state of knowledge only be achieved by nuclear means, since no other power plant could remain independent of the atmosphere for a sufficient length of time. Thus, since the trans-Polar route cuts the passage from London to Tokyo by half, a nuclear submarine with twice the running costs of a conventional vessel might still be economic—quite apart from other considerations of reduced travelling time.

But equally significant is the now proven reliability of the vessel and its power plant, the first nuclear propulsion unit ever made, designed at a time when there were no permanent land-based power reactors in service and experience of reactor operation was fragmentary.

Its designers were required to extrapolate on a grand scale. No doubt every reasonable test was made, but calculation must nevertheless have played a greater part than in any comparable engineering project ever undertaken. There could, for example, have been no direct long-term experience of corrosion by water inside a pressure vessel in the presence of radiation. Yet the Nautilus has now been in service for several years, has travelled many thousands of miles, has been refuelled at least once, and by trouble-free operation has given its crew sufficient confidence to make a hazardous 1,830-mile journey beneath the ice.

Engineering has come a long way since ice demonstrated the inadequate foresight of the engineers who built the Titanic. Empirical data have now been bound together by a vast complex of academic theory, so that the interstices between recorded fact no longer represent voids in our understanding.

Theory has become necessary, not only because we wish to proceed beyond the confines of our immediate knowledge, but because this knowledge has grown so enormous that it can only be communicated or put to use in terms of comprehensive abstractions. The dual character of engineering, balanced between mathematical abstraction and practical experience, has long been apparent, but the two aspects have never been properly reconciled. Engineering students with a scientific background are frequently appalled by the assumptions they are expected to make, and by the bastard rationalisations that are presented to them. But as engineering studies become more profound and an increasing area falls subject to theoretical treatment, the sense of incongruity diminishes. At the same time the engineer's power to foresee is much extended, in spite of the ever more complex and delicate character of engineering products, and the increasingly onerous duties they have to perform.

Like Columbus, who set out westward across an uncharted ocean on the strength of an unlikely theory that the earth was round, the engineer can venture further from his base than ever before. The vision of Jules Verne in *Twenty Thousand Leagues Under the Sea* was perhaps extrapolation of a different kind, but a real Nautilus has made the story plausible—and opened up a new engineering domain.

Cover Picture. *The first stage in the manufacture of the smaller sizes of steel balls for bearings involves the cutting off of billets from a coil of wire. The balls are then formed between two hemispherical dies in fully automatic cold heading presses.*

(*Nurnberg photograph for* ENGINEERING)

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Plain Words

A photograph in a newspaper a few days ago made me despair of other people's good taste and sense of what is right and proper (my own, of course, being unimpeachable). It showed the beach at Southport on August Bank holiday when many motorists took their vehicles on to the beach. A beautiful sandy beach at the seaside, disfigured by all those horrible mechanical boxes—for that is what a car is when it is out of place.

It reminded me of an incident near another beach 16 years ago. A convoy of lorries was moving along the Western Desert coast road. In one of the lorries was an illicit piano, carefully concealed by the tarpaulin. As the Army Commander had only the day before issued an order that no unauthorised furniture, equipment, junk, etc., was to be carried in W.D. vehicles, it was unfortunate when the piano fell out and hit the car of the Chief of the General Staff. Now I will concede that a piano is a machine with a difference—was it Paderewski or Pachmann who said that a piano had a soul? And since Highland regiments carried bagpipes, why not a piano for an English regiment? But hundreds of cars on Southport beach are altogether different. There is no soul in the modern mass-produced car.

You may ask what this has got to do with engineering. Quite a lot, because the same fundamental question is cropping up in other connections, and the engineering firms who make the machines have a direct interest in the decisions. Television cameras are to be allowed into previously forbidden territory—the Houses of Parliament. The will be admitted to the State occasion of the Royal Opening of Parliament; but the Government refuse to allow the every-day business of Parliament to be scrutinized by these mass-communication machines. Quite right, too. On a lower plane, there has been an argument about the propriety of allowing cooking to be performed in the restaurant before the very eyes and noses of the diners. Some fastidious patrons loath the practice, but they seem to be on the losing side.

It would be bad public relations for the profession, if engineers gave the impression that they wished to see their products in the most unlikely places. I think we should err the other way—we should be careful not to violate privacy, quietness, or any amenity which we can easily leave alone. The politician's "rising standard of living" depends largely on engineering, but there is a time and place for everything, including the benefits which we so freely bestow on ignorant mankind. If we respect other people's feelings when we can, they will more readily co-operate when the imposition is a necessary one.

CAPRICORN

Weekly Survey

Summer Lull

At the beginning of last week a number of commentators on the outlook for the rest of this year were taking a mildly optimistic view of the future. The Midland Bank Review, for instance, was talking about the recent evidence of an easing in industrial production as a slackening of tension. Reports from all over the country have been of worries about the immediate future, but optimism about the long term trend. The recent remarks of Sir David Eccles, President of the Board of Trade, when he said recently at a ministerial meeting of O.E.E.C. in Paris that there was a danger of a recession in Western Europe being generated within member countries themselves, were taken seriously enough; but many people are impressed with the evidence that the American recession is coming to an end. They foresee that a recovery in the United States this autumn will take the rest of the world with it.

Since then the official index of industrial production in the United Kingdom has been published for June. It shows a decline of 5 per cent compared with June, 1957. The recession in this country is as yet highly concentrated in coal, steel and the building and contracting industries and unemployment is correspondingly concentrated in certain industries and in certain localities. The present state of many order books and the known fact that the building industry is still going through a quiet time makes the immediate outlook for the capital goods industries somewhat gloomy. On the other hand there are a large number of capital equipment schemes on the railways, on the roads and in atomic energy which are still creating a substantial demand for equipment and even coal and steel have not cut back their development programmes. It is just possible that a recovery may take place in building and civil contracting to offset the decline in investment in other directions. In the meantime the motor vehicle industry is performing a valuable holding operation in maintaining a high level of activity over the wide range of ancillary industries which provides its components.

Steel Slow-Down

The change in the economic climate which took place in 1957 has had the effect of slowing down the carrying out of the steel industry's expansion programme by about a year. In their annual report for 1957, the Iron and Steel Board point out that demand for steel in 1962 is expected to be lower than the 30 million tons forecast a year ago and that the expansion in the capacity of the steel industry in Britain is likely to fall short of the 29 million tons which had been planned by 1962-63. The decline in the demand for steel products towards the end of last year has continued and the industry, as a whole, is currently working at no more than 80 per cent of capacity. This, the Board comment, is "bound to affect the carrying out of the programme in some degree." Several new projects, in fact, have been delayed and one or two others have been modified by postponing the installation of some of the equipment. The Board estimate that "on the basis of schemes already approved" the capacity for crude steel should be about 27 million ingot tons in 1962, rising to between 27½ and 28 million tons in 1963. Capacity last year was 22½ million tons.

The review of the industry's development plans contained in the report is a most interesting case study of the inevitable effect of fluctuations in economic activity, however temporary they may prove to be, on an industry's long-term plans. The steelmakers' doubts on the accuracy of official estimates of the nation's industrial expansion were commented upon in Weekly Survey on 8 August. "There has not unnaturally been less assurance," the Board state, "about the extent of the market in 1962 and financing arrangements have been rendered more difficult." This financing problem has been accentuated by the uncertainty caused by the possible effects of political changes on the affairs of the industry. In this connection, the Board's review of the industry's price policy under the heading of "Costs and Prices" is most revealing. The raising of prices over the whole range of the industry's products by an average of 7½ per cent on 26 July was designed to cover an increase in costs of some £55 million, as well as an increase of approximately £10 million a year in the provision for depreciation and obsolescence; this provision being necessitated by a reassessment of the probable effective life of plant "in the light of the technical changes which have occurred or are in prospect." If all existing plant had to be replaced to-day by new plant of the same output capacity, the cost at current prices would be of the order of £1,600 million. The provision in 1957 for "depreciation, obsolescence and profit before tax" remained at 14 per cent; the same proportion as in previous years.

It is the considered view of the Board that "maximum prices should neither justify inefficient production nor discourage expansion and modernisation," and they point out that current development needs and the practical means of satisfying them may lead to modifications of their price policy. Financing expansion, and creating the necessary climate under which it can take place, summarises the Board's main problem.

Maltese Docks

The future of the Malta dockyard is of primary importance in the economic and political development of the island, as was shown by the recent unrest when it was announced that naval work would decline after 1960. Particular importance therefore attaches to the plans announced earlier this month under which, subject to a satisfactory agreement, the naval dockyard will be converted to commerical use and will be transferred to the ship repairing company C. H. Bailey Limited, dry dock owners and ship repairers at Newport Monmouthshire and Barry Dock. A new company is to be registered in Malta to take over the dockyard on a long lease and Vice Admiral Sir Gordon Hubback, the member of the Board of Admiralty who deals with the dockyard, is to be released to become managing director.

The plan should thus ensure continuity of administration while bringing in the commercial experience of a company first registered (as a private company) some 35 years ago. The total cost of conversion and re-equipment for commercial use is estimated at about £5½ million of which the British Government will provide £4¾ million, partly in the form of a debenture and partly as a grant, while C. H. Bailey in conjunction with the Colonial Development Corporation and certain Maltese interests are expected to provide the remaining £¾ million.

It is expected that C. H. Bailey will take over full responsibility for the yard during 1959 and the chairman of the company has stated that they hope to make Malta one of the best engineering ship repairing centres in the world. He pointed out that the island is well placed on the sea routes and that developments in North Africa, particularly in connection with Algerian oil, will greatly increase the number of ships passing through the Mediterranean. The success of the scheme clearly depends on future political developments on the island but it clearly offers one of the best prospects of maintaining employment when naval work begins to decline.

Steering Government Research

A change is to be made in the method of obtaining advice on the control of the laboratories of the Department of Scientific and Industrial Research. In the past this advice was given by large boards representing a number of interests. A simpler system is to be tried out at the National Chemical Laboratory (formerly called the Chemical Research Laboratory) and the Warren Spring Laboratory to be set up at Stevenage. In the case of the National Chemical Laboratory the board had a membership of 20 including assessors. There are now to be steering committees of five members each, including the chairman, who will also be a member of the Research Council which is the central executive body established under the Department of Scientific and Industrial Research Act 1956.

The new arrangement by which small committees and even sub-committees can be made directly responsible to the Council is being tried out as a method of implementing the intention of the 1956 Act, which puts the responsibility for action directly on the Council. The steering committee for the National Chemical Laboratory takes over responsibility on 1 October under the chairmanship of Professor C. E. H. Bawn with Dr. R. Roffey and Mr. B. Topley as members along with the secretary of the department, Sir Harry Melville, and the director of the laboratory, Dr. D. R. Pratt. The steering committee for the Warren Spring laboratory assumes responsibility at once since it is controlling a new venture. The chairman will be Sir Harry Jephcott and the other members Dr. R. Holroyd, Mr. D. A. Oliver, Sir Harry Melville and the director of the laboratory, Mr. H. S. Clarke.

Too Much Coal in Germany

The problem of declining coal consumption and rising stocks which has faced the National Coal Board over the past year is also becoming acute in Germany. At the end of July pit-head and consumer stocks in the Ruhr amounted to 20 million tons, of which pit-head stocks accounted for 8·25 million tons compared with about 1·5 million tons in February. Present stocks are said to be higher than at any time in the history of the Ruhr, not excluding the 1932 depression.

Although some reduction in output was made at the beginning of this year, short-time working is not yet serious and is estimated on average at a reduction of about one shift per month. If stocks continue to rise, however, it will not be long before more drastic measures become necessary. In order to alleviate the position it has been suggested that the three coal syndicates should buy coal from the mines and send it to Southern Germany for storage until required. Unless, however, there is a marked improvement in consumption such measures will only postpone the need to reduce production and may lead to a more drastic curtailment of output than would be necessary now.

Apart from the slackening in German industrial activity, there has been a marked fall in exports of German coal. Imports have been increasing, too. American coal has for some time been cheaper than German in some parts of northern Germany and in some export markets, and the disparity in price has widened recently with the fall in freight rates. Thus the excess of German exports over imports was only 1·6 million tons in 1957 compared with 18 million tons in 1954.

This situation may shortly provide a serious test of the German Government's policy of maintaining free trade. Coal producers claim that contracts are still being made with United States coal exporters at the rate of 7 to 8 million tons per annum. Backed by leaders of the miners' union, they are asking for Government control of imports. In view of the dispute at the end of last year between the Government and the coal owners over the raising of coal prices, the Government may not readily accede to this request.

Talking Turkey

Turkey lies geographically between Western Europe and the Middle East. So far as the former is concerned it is one of the so-called peripheral countries which require special treatment because of their lack of industrial development. Unlike its neighbours in the Middle East it has no oil revenues to raise the national income. In the last few weeks Turkey has run into a serious balance of payments problem from which it has been rescued by a grant of 100 million dol credit from O.E.E.C. to be made available through the European Payments Union. At the same time the International Monetary Fund has approved a grant of 25 million dol and the United States has come through with credits amounting to 234 million dol.

One of Turkey's problems is an out-of-date exchange-rate system that gives unrealistically high values to the currency. The official rate for tourist exchanges is 5½ Turkish pounds to the dollar. On overseas free markets the rate has been around 17 Turkish pounds to the dollar for the last eight months. The result has been a flood of imported foreign goods, while the Turkish manufactures have been priced right out of overseas markets. Now a new exchange-rate system is to be introduced with a devalued range of values for different types of import. For export goods devaluation will be on a less drastic scale. It is to be hoped that with the 360 million dol of foreign aid it has received and the prospect of an increased income from overseas trade, the Turkish Government will be able to stabilise the financial position.

Spending on the Social Services

So far as industry is concerned, there are two important questions to ask about social-service spending. One is whether we are spending so much that our competitive ability is affected, the other is whether capital investment in the social services diverts too much money away from investment in new machinery, roads, railways and all the other things needed if industry is to work effectively. Answers to these questions are to be found in an article in the current issue of the Treasury's *Bulletin for Industry*.

In 1957/58 current expenditure on the social services amounted to 14·2 per cent of gross national product. The figure for Western Germany given in an I.L.O. report issued in 1956 was 20 per cent, for France 16½ per cent, and Britain in fact was the seventh among Western European countries in the amount of money spent on the social services. The three biggest items are national insurance, which takes 29 per cent, education 24 per cent, and the national health service also 24 per cent. All told the article says that over £50 a year a head is being spent on the social services, about half this is spent by the central Government, the rest through the local authorities and the national insurance funds. All this represents an increase of 70 per cent over the last 7 years.

Now when we turn to our second question the position is that capital expenditure was £421 million in 1957/58. This represents about half the capital expenditure of central and local government and about one-seventh of all capital expenditure in the country. Almost all of this went on local authority housing and education. Is one-seventh too big a slice of capital investment to go on the social services? The answer depends on whether we are getting as a result a more mobile labour force and a better educated young entry into industry. The present trend is for local authority house building to decrease but spending on schools has continued to rise.

Letters to the Editor

RAILWAY ACCIDENTS

SIR, One aspect of the probable cause of several railway accidents seems to have been overlooked, and that is the practice of not fitting locomotives with a speedometer. It is quite likely that the unfortunate driver of the locomotive involved in the Lewisham crash was honestly under the delusion that he was travelling at a much lower speed, owing to the density of the fog and to the absence of landmarks by which to judge his speed. Had his speed been lower he would have been able to pull up when suddenly confronted with the red signal. I hope the Railway Executive will not dodge the question by saying this would divert the driver's attention; the same argument could be applied to the various other gauges fitted in the cab.

Every year we have several cases of trains running into buffers at termini—in to-day's paper two such accidents are reported, and there is a photograph of a Pacific-type locomotive having mounted the buffers at York. What surprises me after well over a century of railway operation is the crude buffer stops which are provided at the majority of terminal stations. Fifty years ago, elaborate hydraulic buffers were installed at the old St. Paul's Station in the S.E. & C.R. days, and the locomotive of the early morning train I used to travel by tested their operation.

It seems strange that their adoption never became universal. I suppose the old argument will be applied, that the likelihood of a train crashing into the buffers is so small that the extra cost would not be warranted.

Yours faithfully,

J. F. PERRIN.

6 Cavendish Avenue,
Welling, Kent.
5 August, 1958.

SIR, In your leading article on 1 August (p. 129), you comment on the report of the Chief Inspecting Officer of Railways on the accident at Lewisham, and suggest that it is superficially easy to blame Driver Trew for making an error which may well be due to failure to appreciate the limitations of human performance under stress.

Actually, the Chief Inspector is inconsistent in his report and himself demolishes his own finding when he says that had Driver Trew been in charge of an electric or diesel locomotive the accident is unlikely to have happened. The implication of this is that the design of the steam locomotive and the layout of the signals was such that the task of the driver was made more difficult than it should have been, and for this the blame must lie with the management and the engineers responsible.

For the efficient human operation of any equipment, the demands of the situation must be well below the capabilities of the operator, so that, under conditions of stress, failure will not occur. This was clearly not the case at Lewisham. Vision from the cab of the locomotive was poor and the signals were placed where the driver could not see them from his normal driving position. No mention is made of any form of speed indicator but, if normal railway practice was followed, none would have been fitted. In the complete absence of visual cues, how could the driver know his speed or position ? These are all poor design features which make the task less easy than it could be, and one which was potentially dangerous. If much further stress is added failure must surely be inevitable. At Lewisham this stress was present in the form of fog and age, either of which, taken alone, might not have been sufficient to cause breakdown. Taken together the result was disastrous.

As your leading article points out, the concept of the human operator as a communication channel of limited capacity is useful in clarifying situations of the type under discussion. An additional concept of "noise" helps one to

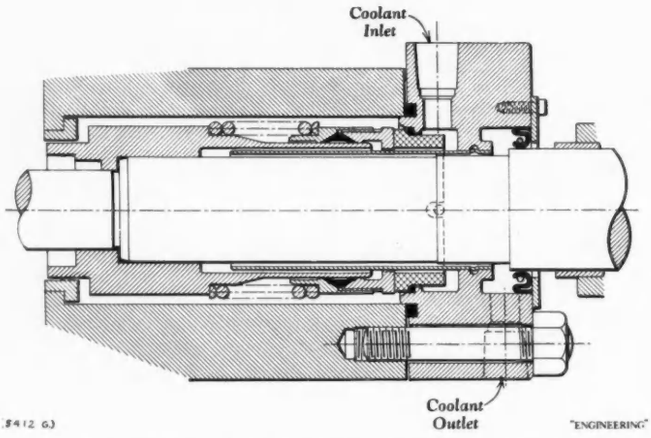
Plant and Equipment

COOLED MECHANICAL SEAL

A mechanical seal that will operate at temperatures in excess of 800° F and at pressures up to 800 lb per sq. in has recently been developed by Flexibox Limited, Nash Road, Trafford Park, Manchester, 17. The seal, which is shown in the accompanying illustration, does not require the pumped fluid to be circulated past the seal faces, and the normal water-cooled jacket around the stuffing box is retained.

Designated type RRH, this addition to the firm's range of products differs from the standard type RR in that it is fitted with a special cooled sleeve. Cooling water introduced by way of the seal plate is made to pass under the seal components, and between the seal sleeve and the shaft. In effect, this process forms a cooling jacket around the shaft, so maintaining the seal faces at a comparatively low running temperature, while the equipment itself is handling fluids at much higher temperatures. The reduced shaft temperature also results in longer bearing life.

Applications include high-temperature, high-pressure process pumps handling petroleum fractions, gases and chemicals, and boiler feed pumps for conventional and nuclear power stations.



Mechanical seal for high temperatures and pressures.

DUAL PIVOT LOADER

A dual pivot loader capable of overhead and front-end loading is announced by David Brown Construction Equipment Limited, Hanworth Park, Feltham, Middlesex, for use with the David Brown 900 industrial tractor with "live" hydraulic system. The loader has a $\frac{3}{8}$ cu. yd dirt bucket as standard equipment, but a $\frac{1}{2}$ cu. yd light material bucket, 'dozer blade, bucket teeth and radiator guard are also available.

Bucket roll-back and automatic level carrying positions at all heights are features of the loader, which is capable of discharging at the rear in a lifting time of 14 seconds or at the front in six seconds. Maximum break-out load using the bucket rams is 2,500 lb at the bucket tip and a maximum load of 1,250 lb is specified in loading to a height of 9 ft. The main lift rams and bucket control rams are double-acting. A maximum hydraulic pressure of 1,400 lb per sq. in is delivered by a constant driven gear pump,

Both overhead and forward discharge are possible with the dual pivot loader attachments.

and the two-plunger valve has double-lever control. The loader is fitted to the four standard pick-up points of the 900 industrial tractor, and support frames are fitted to three cross-shafts which provide a pin-jointed triangular structure.

SILICON POWER RECTIFIERS

Five types of high-current silicon rectifiers are now being produced by the rectifier division of Sarkes Tarzian, Incorporated, 539 South Walnut Street, Bloomington, Indiana, U.S.A. All have the common features of imbedded construction, to withstand shock and vibrations; a choice of positive or negative base polarity to simplify connection in full-wave or polyphase circuits; and special sealing gaskets to protect the base contact.

The R type has a base d.c. rating of 20 A maximum, with an inverse voltage range from 50 to 300 volts, and the S type has the same inverse rating for a current of 35 A and can be used with either forced or natural cooling. The V type is rated at 100 A for peak inverse voltages of 50, 100, 200 and 300 volts; forced cooling being required for these and all higher ratings. The W rectifiers cover up to 150 A for the same range of inverse voltages, and the X type is designed for a half-wave rating of 200 A, making possible 900 A loads in six-phase circuits. Inverse-voltage ratings for the X type are the same as those for the V and W rectifiers.

Continuing Letters to the Editor

understand why the additional stresses of fog and age might prove crucial when superimposed on the already existing "noise" caused by bad job design. This theoretical model, while providing a *rationale* upon which preventive measures might be based, is of secondary importance to the general appreciation of the fact that man must be considered in designing a job of any kind; whether it be as driver of a steam locomotive, as operator of a milling machine, or as housewife in the kitchen.

To ergonomists who study human performance the occurrence of the Lewisham accident is not surprising. Given all the circumstances, it would not have been unpredictable. Similar accidents will occur under like circumstances, unless greater attention is paid, by management and designers alike, to human limitations. Enough is now known to reduce the chance of accidents such as that at Lewisham occurring, and this knowledge could best be applied and augmented by following the suggestions made in your editorial for the employment of human scientists on problems of rail transport. It should not be overlooked, however, that situations similar to those on the railways occur in most human activity, and it is equally important that all designers should work with the human element in mind.

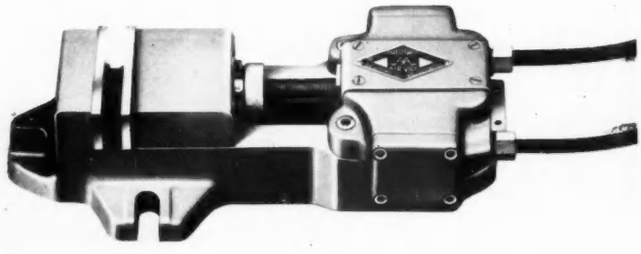
It is grossly unfair to lay the whole blame for the Lewisham accident on the driver, when the fault must lie squarely on management and their designers for failing to make use of the data which is even now available.

Yours faithfully,
K. F. H. MURRELL.
Unit for Research on Employment of Older Workers,
The University, Bristol.
6 August, 1958.

SMALL PNEUMATIC VICE

The "Pneugrip" air-operated vice, made by Air Automation, 26 Sharrocks Street, Wolverhampton, is specially designed for use on small machine tables, and is only $10\frac{1}{2}$ in long, $4\frac{1}{2}$ in wide and $2\frac{3}{4}$ in high. It has interchangeable jaw plates $2\frac{1}{2}$ in long by 1 in deep and a jaw opening of $1\frac{1}{2}$ in. To ensure the safety of the operator, the power stroke is $\frac{7}{64}$ in and the vice remains locked should the air supply fail. A thumbscrew is provided to enable the jaw opening to be set quickly as required. With an air line pressure of 80 lb per sq. in the vice, operating through an enclosed toggle action, develops a jaw-closing force of over 1,350 lb. There is no lifting of the workpiece or jaw when the vice is operated, as the thrust is applied immediately behind the jaw. The return stroke is power operated as well as the clamping stroke.

A four-port manual valve is available for controlling the vice. This valve can either be fitted to the vice itself or supplied for remote fitting in any other position required. In either case the exhaust port can be connected, by means of $\frac{1}{8}$ in diameter copper tube to a suitable position near the jaws, so that the exhaust air can be used for swarf blow-out.



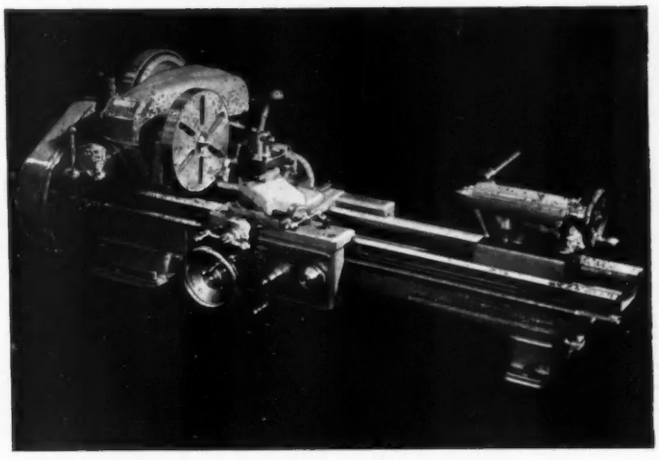
Small overall size makes the "Pneugrip" air-operated vice particularly suitable for use on small machine tables.

Continuing **Plant and Equipment**

HIGH PRECISION LATHES

A range of small lathes now being made by Murad Developments Limited, Stocklake, Aylesbury, Bucks., has been named Antarctica to honour the fact that they were chosen by the Trans Antarctic Expedition for use at the base camp. There are three lathes in the series, one a standard bench model, the second a bench model but mounted on a cast iron tray for complete rigidity, and the third mounted on a cast iron pedestal. The general specification is common to all but the spindle speeds of the tray and pedestal mounted models are higher than those of the plain bench model.

For all three the height of centres is 4 in. swing over the bed $8\frac{3}{16}$ in diameter, and swing over saddle $4\frac{3}{8}$ in. The maximum length between centres is 18 in and the hole through the spindle is $\frac{13}{16}$ in diameter. Power is supplied by a $\frac{1}{2}$ h.p. motor running at 1,420 r.p.m., and spindle speeds range from 39 r.p.m. to 1,300 r.p.m. for the bench model, 2,000 for the tray-mounted version and 2,500 for the pedestal type. The standard set of change wheels will cut threads from $2\frac{1}{2}$ to 96 t.p.i. and includes a wheel for metric conversion. The rotation of both spindle and lead screw can be reversed. A wide range of additional equipment is available, including a taper turning attachment.



The Antarctica series of lathes will take work up to 18 in between centres and $4\frac{3}{8}$ in diameter over the saddle.

ALUMINIUM PLATFORM TRUCK

A lightweight double-ended six-wheel platform truck has been developed by Industrial Trucks Limited, Essex Road, Acton, London, W.3, with the co-operation of the Product Development department of T. Wall and Sons (Meat Products) Limited.

The double-ended truck is constructed of high-duty aluminium alloy which, because of its hygienic qualities, is very suitable for use in the food industry. It has a smooth surface, so that scraps of food cannot lodge anywhere, and it can be hosed down very quickly and thoroughly. Stains are washed away in a few seconds. There is a gap at either end between the angled aluminium support and the platform allowing water to run away. The truck can be anodised if required to resist chemicals. It can carry loads up to 10 cwt.

The truck moves on six rubber-tyred heavy duty wheels to avoid the possibility of side tip. The two centre wheels, which are 8 in in diameter, act as a pivot so that the truck can be turned round in its own area. The dimensions of the " Aerolumin " platform truck are: length 53 in, height 42 in, width 27 in.

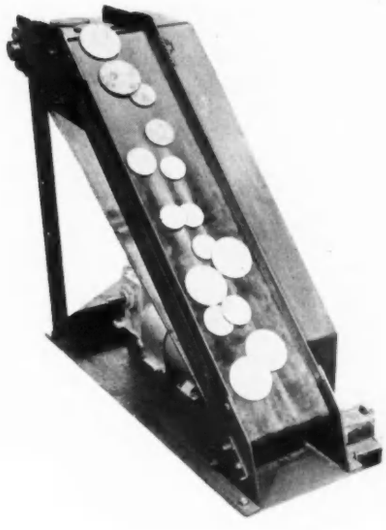
MACHINE VICE

A tilting and swivelling machine vice for heavy loads has been introduced by A. A. Jones and Shipman Limited, Narborough Road South, Leicester. The vice has a jaw width of 4 in and admits work up to 3 in. The vertical movement is 90° and rotation is possible through 360°. The centrally-disposed Acme thread locking shaft has both master and auxiliary locking nuts to allow quick positioning. Both are operated by a tommy bar. The auxiliary nut locks the swivelling base only, leaving the tilting member free, and the master provides a solid lock for both swivelling and tilting movements.

MAGNETIC CONVEYORS

For the elevation of awkwardly shaped steel parts up steep inclines, and particularly where space has to be conserved, a magnetic conveyor has been developed by Geo. Robson and Company (Conveyors) Limited, Eclipse Engineering Works, Hodgson Street, Sheffield, 3. An example is shown in the accompanying illustration (right).

Basically, the conveyors consist of a flat belt sliding over a flat plate under which are a series of permanent magnets. Even heavy articles are held against the belt by this means and so are carried up the slope. In fact, it is possible to run the conveyor vertically. Any magnetism imparted to the articles can be removed by a demagnetiser at the top or at the discharge point. So far, the widest conveyors made by the firm have had 24 in belts and were for handling oily steel off-cuts.



Magnetic elevator for handling steel articles at very steep angles.

LIGHTWEIGHT SIGNALLING LAMP

A new lightweight high intensity signalling lamp for air traffic control, now being marketed by the General Electric Company Limited, has a maximum intensity of 130,000 candelas. It has been tested successfully over a distance of 4 miles transmitting signals into bright sunlight. The lamp, which weighs $4\frac{1}{2}$ lb, has been designed for easy use in the hand, and with an overall diameter of 7 in and a barrel length of $7\frac{3}{4}$ in, it can be operated in the confined space of a control caravan.

The lamp (known as type ZA.702) houses a $6\frac{3}{8}$ in diameter anodised aluminium reflector which produces a narrow well-defined beam minimising the risk of signals being received by two adjacent aircraft simultaneously. This risk is reduced further by the inclusion of special shutters for signalling in morse or any other code, instead of the more usual tilting-reflector mechanism. The shutters are actuated by a spring-loaded mechanism to give rapid movement and it is claimed to be impossible to transmit confusing signals by incorrect operation of the trigger. The pistol-grip handle has a special hand-grip by means of which the lamp is switched on and off.

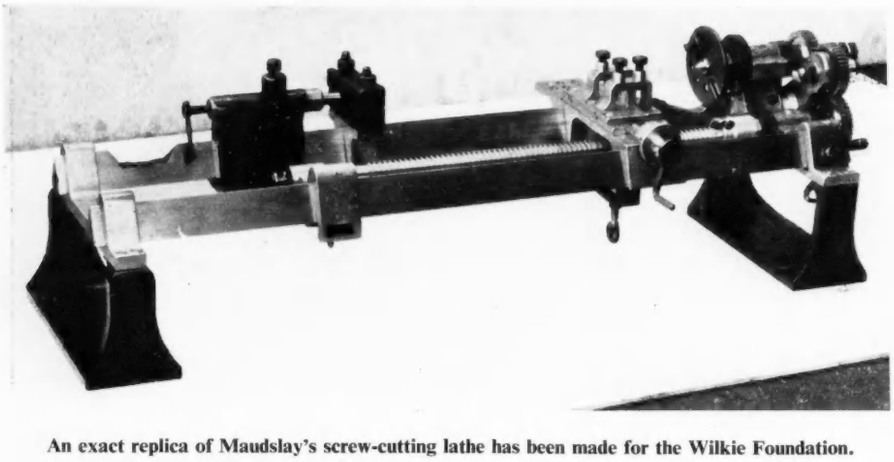
By rotating another handle beneath the front of the lamp, red or green colour screens are brought into position over the normal white light while the lamp is held steadily in both hands. An indication of the colour being transmitted appears through an aperture at the rear of the lamp-housing, beneath the eye-piece of the sighting unit.

The lamp houses an Osram 6V 45W bulb. To change the bulb it is removed in its holder, as one unit, by loosening three knurled nuts. There are no flexible connections in the lamp housing and there are no electrical connections in the main operating handle. The flexible cable is connected to the bulbholder by a socket fitted with a screwed locking ring.

The signalling lamp can be supplied either for holding in the hands or with a fully counterbalanced ceiling suspension system which allows the lamp to be used at any height between 4 ft and 9 ft above floor level. Suspension is by means of a Terylene cord attached to a counterweight.

Continuing **Plant and Equipment**

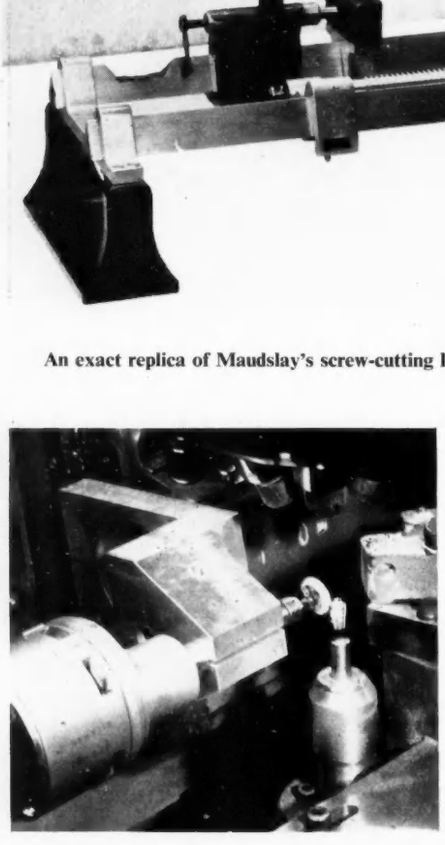
REPLICA OF MAUDSLAY'S LATHE



An exact replica of Maudslay's screw-cutting lathe has been made for the Wilkie Foundation.

A full-scale reproduction has been made of the metal screw-cutting lathe produced by Henry Maudslay in *circa* 1800. It was made to the order of the Wilkie Foundation, Des Plaines, Illinois, U.S.A., by the firm of George Wailes and Company Limited, 382-388 Euston Road, London, N.W.1, and is practically indistinguishable from the original, now in the Science Museum.

The use of a lead screw was suggested by Leonardo da Vinci in a drawing *circa* 1489 though as far as is known nothing practical came of it. The idea was also put forward by Besson in 1569 and was used in a fusee engine invented in 1741 for turning the spirals of fusees in clocks. Senot's lathe of 1795 can still be seen in Paris and David Wilkinson produced one in the United States in 1798, but as far as is known, Maudslay was unaware of these, though he was probably acquainted with the fusee engine. This screw-cutting lathe was the first engineering machine tool to be made entirely of metal, and marked the abandonment of wood in machine tools, with a consequent great improvement in accuracy. It was the first practical and successful screw-cutting lathe and became the forerunner of a whole series of machine tools which made Britain the principal supplier for many years.



An attachment is now available for grinding very small radii.

GRINDING SMALL RADII

An attachment has been produced for the optical grinding machine made by Wickman Limited, Banner Lane, Tile Hill, Coventry, to enable very small radii to be ground accurately. The set-up is shown in the illustration. It consists of a motor and wheel head that fit in the place of the standard head but will accommodate wheels ranging from $\frac{1}{4}$ in to $\frac{3}{4}$ in diameter which have $\frac{1}{8}$ in diameter shanks. The spindle speed is 35,000 r.p.m. under load, and the motor is rated for 220 volts single phase. An alternative version is for 110 volts.

TORQUE LIMIT PULLEY

A new "torque limit" pulley for drive or countershaft mounting is now being marketed by Industrial Drives Limited, 44 Uxbridge Road, Ealing, London, W.5. Its intention is to provide a slipping clutch to prevent damage if machinery should seize. The assembly consists of a cast-iron pulley and cone clutch mounted on a mild steel combined sleeve and retaining shaft. The clutch assembly is held under pressure by a steel spring, the force of which can be regulated with a screwed knurled collar.

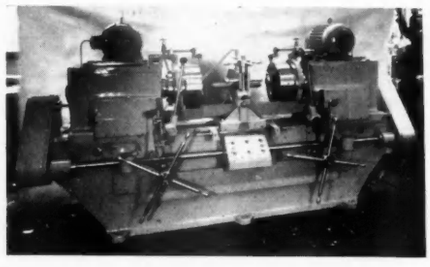
The torque limit unit fits directly on to the drive shaft or countershaft in the same way as a conventional pulley. When the unit is in position, the break-away or safety torque is adjusted by releasing the setscrews and turning the adjusting collar to the required setting.

CUTTING RIGHT AND LEFT-HAND THREADS

Designed primarily for the production of railway-vehicle couplings, the Duplex screwing machine now being made by Joshua Heap and Company Limited, Oldham Road Engineers' Tool Works, Ashton under Lyne, will cut right and left-hand threads on a workpiece simultaneously. The general arrangement is shown in the accompanying illustration.

Essentially, the machine consists of two headstocks with individual drives feeding under lead-screw control from their own spindles. In each is a tangential diehead of the firm's standard pattern, in which the die-holders are mounted in trunnions and enclosed by solid cam-rings that absorb the cutting strains. This arrangement allows the 7 mm metric threads for the couplings to be cut in one pass on the 50 mm En16T steel shank at a surface speed of 7 ft per minute.

Each headstock is driven by a 5 h.p. motor through V-ropes; there is a choice of nine speeds. The final drive to the main spindle is through a precision worm and wheel. The threading operation is initiated by engaging both lead screws; at the end of the cut both the lead screws



Right and left-hand threads are cut simultaneously.

and the dieheads are tripped automatically, and the headstocks are returned to their original positions by the rack and pinion. This last operation could also be power operated.

The coupling screws, or whatever the work is, are held rigidly in a vice, and since the torque is all in one direction either a central peg or a pair of flats must be provided to prevent rotation.

ALUMINIUM CONDUCTOR ACCESSORIES

A new range of accessories for use with aluminium conductors is now available from the Northern Aluminium Company Limited, Banbury Oxfordshire. To be known as the Noralgrip range, they supersede the former Tubular range and have been approved by the Central Electricity Generating Board. They are designed for use on e.h.v. overhead lines and earthwire conductors and include deadends, midspan joints and disconnectable non-tension joints. All contact surfaces are pretreated for making quick joints and covered with a protective plastics film before leaving the factory.

The firm have also produced a portable compressor unit for use in connection with these accessories. This consists of two plunger pumps driven through eccentrics by a Villiers 7F two-stroke engine. Alternatively, an electric motor can be fitted. Pressures up to 7,800 lb per sq. in are obtainable, giving a capacity of 100 tons at the ram head. Ram and pump are connected by a short length of flexible hose and the two items are mounted on a carrying frame. For overhead work the short hose can be replaced by a longer one to enable the ram to be taken to the work. The complete compressor is shown in the illustration.

For making compression joints for the Noralgrip conductor accessories, a ram force of 100 tons can be developed.

The Human Element

Miss Smith, M.I.E.E.

The belief expressed recently by the Science Masters Association (Human Element, 1 August —" Tools for Teaching Science ") that there was a vast store of engineering talent among our womenfolk, is supported from time to time by the achievements of individual women engineers. Just a year ago, Miss Mary Fergusson was the first woman to be elected to full membership of the Institution of Civil Engineers. Now Miss Dorothy Smith, of the motor engineering department of Metropolitan-Vickers Electrical Company, has been elected to full membership of the Institution of Electrical Engineers. No woman has achieved this distinction since Miss Ayrton in 1899.

Miss Smith joined Metrovick in 1916, straight from school, with a keen interest in mathematics. Since 1927 she has been a member of the development section of the motor engineering department and was one of the team responsible for the development of the R-type induction motor. She has since worked on the development of a wide range of direct-current and alternating-current rotating machines. Part-time studies at Manchester College of Technology enabled her to become an associate member of the I.E.E. She joined the Women's Engineering Society in the early 1920's, was chairman of the Manchester Branch from 1943 to 1945, and has been a member of the council since 1947. This is no mean achievement and something for our girl science students to emulate.

Clash Over Craftsmanship

Trouble has broken out among the printing unions about skilled and unskilled workers. Natsopa, the 44,000 strong operative printers society, has withdrawn from the Printing and Kindred Trades Federation. This means a loss to the federation of its third largest union, and a corresponding lowering of hopes about agreement among the unions on a two-tier wages structure, which would solidify skilled and unskilled rates into two permanent grades.

Natsopa is largely a non-craft union although it has some members who do skilled work. This union favours a single-tier structure which would do away with craft differentials. The immediate cause of the break has been the exclusion of Natsopa from a recent conference within the federation on the grounds that it was not a craft union.

Despite this setback to ultimate unification, the craft unions are continuing to work out the details of amalgamation which is expected to take several years to thrash out. A committee is drafting the principles of a merger and ahead of that is the long road of inter-union negotiation.

Training for the Railways

A new apprentice training centre was opened last week at London Transport's central railway overhaul works at Acton by their chairman, Sir John Elliott. The building, which can accommodate 25 apprentices, will be the centre for all instructional facilities for apprentices undergoing training.

The apprentice training scheme of the department of the Chief Mechanical Engineer (Railways) was reviewed and re-organised in 1947; the number of apprentices was increased and the number of trades taught extended to nine. The present establishment allows for 112 apprentices, based on a five-year course; the majority are in the mechanical fitting, electrical fitting, and bodymaking trades, with a minority spread among sheet metal working, armature winding, coach painting, coach trimming, wood machining and blacksmithing. Most boys now enter Acton works directly from school, but they are interviewed well prior to taking up apprenticeships, normally at the age of 14. This enables each boy to receive advice for some two years in advance, as well as during his apprenticeship, on matters affecting his career. The necessary close liaison is maintained with the schools.

The new training centre is particularly well equipped and pleasantly designed. Each apprentice will spend between three months and one year at the centre, and the balance of his apprenticeship in the works. At the centre he will receive an introduction to workshop conditions and a good grounding in basic workshop principles. He will also receive instruction in the care and use of hand tools and, where applicable, machine tools. The concentration of instructional work this makes possible will be particularly valuable for the provision of advanced specialised tuition in the later stages of the apprenticeship. The training centre will be run by Mr. B. Williamson, apprentice supervisor, under the general supervision of Mr. G. S. Bingham, Mechanical Engineer (Works—Railways), with Mr. C. I. Birkbeck as apprentice controller.

Legislation on Litter

The way of the parliamentary draftsman who tries to protect the countryside is hard. It is not easy to legislate for a higher standard of public responsibility so far as the public amenities are concerned. Municipal engineers, on whom falls much of the burden of organising the collection and disposal of rubbish, must look forward to the successful implementation of the Litter Act of 1958.

The Minister of Housing and Local Government has drawn the attention of local authorities to their powers under this Act to prosecute people who drop litter. It is now an offence to drop unauthorised litter in or from any place in the open air to which the public are entitled to have access without payment. On summary conviction the offender is liable to a fine of £10.

One of the niceties of the Act is the definition of " open to the air." It includes bus shelters which are open at one end. If anyone therefore has a sudden urge to throw away a bus ticket he must be careful to choose a bus shelter which is reasonably enclosed. One imagines too that there may be a certain amount of difficulty with the phrase " unauthorised litter." The litter lout in places of beauty and so on has now been brought under some sort of control. It is still necessary to consider the case of rubbish thrown down in places which are not covered by the phrase " open to the air "—or to interpret the provisions of the Act as widely as possible. If bus shelters are included, so ought railway stations to be, and other places of public concourse.

Young Man's Burden

The report for 1957 of the Ministry of Pensions and National Insurance points once more to the growing burden of the ageing population on the younger generations. Much has been made in the report for last year of the fact that the Asian 'flu epidemic cost the nation about £10 million in charges to the health service alone. This is, however, a passing phase. What is more significant is that last year 424,000 new retirement pensions came into payment and that this raised the number of people receiving pensions to about four and three-quarter million. Of the £622 million paid out in the year ended 31 March 1957 on national insurance benefits, nearly £448 million was devoted to retirement pensions. This was an increase of £15 million on the year before and an indication of a trend which has set in for many years to come.

In December 1957 there were 201,000 people receiving unemployment benefit compared with 168,000 in the year before. Altogether it was a year of heavy outlay on the insurance fund. In the year up to 31 March 1957 the income of the national insurance fund was £733½ million, while payments came to £700 million. Over £96 million of the income came from Exchequer contributions.

Protective Boycott

Increasingly trade unions are taking a hand in seeking to protect their industries from foreign competition. Last week both the shipbuilding unions and the cotton manufacturing unions initiated action designed to fight off competition which their industries cannot meet on level terms.

Leaders of the shipbuilding unions passed a resolution calling for an international conference to consider a world-wide ban on the building and repairing of ships operated under " flags of convenience." Mr. Hill, general secretary of the Boilermakers Society, who proposed the resolution, called the practice of operating ships under the flags of countries which have very low rates of tax and which are not bound by international agreements on seamen's pay and conditions " no less than piracy." " We have got to do something about this," he said, " or the whole future of British shipping will be undermined." The move followed a decision of the International Transport Workers Federation in Amsterdam to impose a boycott on all " flags of convenience " vessels. This will probably mean the withdrawal of all labour services, including unloading facilities and transport from these ships. The shipbuilding unions' support action will be considered by the executive of the International Metalworkers' Federation in Geneva.

Cotton unions met to consider what steps could be taken to protect Lancashire from the effects of cheap cotton imports. The secretary of the United Textile Factory Workers Association, Mr. J. Milhench, said that a sub-committee had been appointed to examine what could be done to limit imports and would make their recommendations to the union's council at the end of August. Already the co-operative movement have begun a boycott of imported cotton goods (the Colne and District Retail Co-operative Society) and further action of this kind is likely.

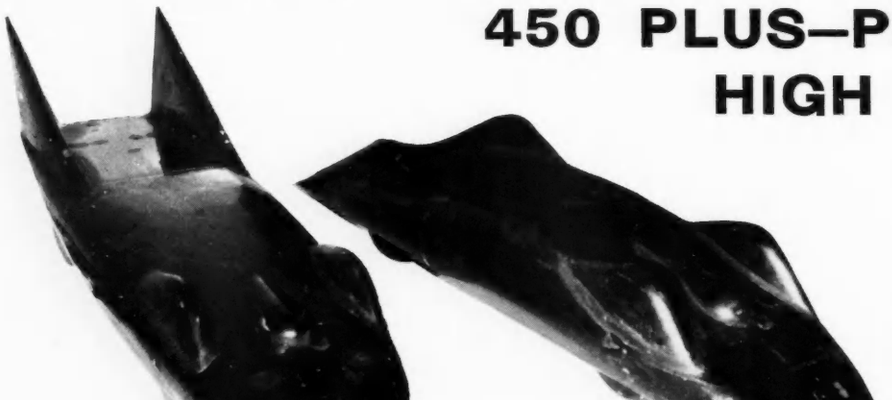
Geiger at the Graveside

Great technical developments occasionally rub shoulders with the macabre and the matter of fact. So it is with atomic energy. The United States Department of Commerce, through the National Bureau of Standards, has issued a booklet called *Safe Handling of Bodies Containing Radioactive Isotopes* " a guide for surgeons, pathologists and funeral directors."

Gruesome as such topics may be from one point of view, they suggest that human beings are coming to some sort of terms with atomic energy and the problems of radiation, as they apply to the human body—or at least the corpse. The practical application of radioactive isotopes has already become more acceptable to the layman, who is used to their constructive role in research and medicine. But complacency can still give rise to dangerous accidents, and the understanding and strict enforcement of safety regulations in connection with radiation are of paramount importance.

Now that radiation has become the concern of both surgeon and undertaker, it is apparent how integral a part of life—and death—atomic energy has become. It is being reduced to terms in which the human race can think of it as a commonplace. But it does not mean that familiarity must be allowed to breed contempt, and hence indifference.

Automobile Engineering



450 PLUS—PROBLEMS OF HIGH SPEED CARS

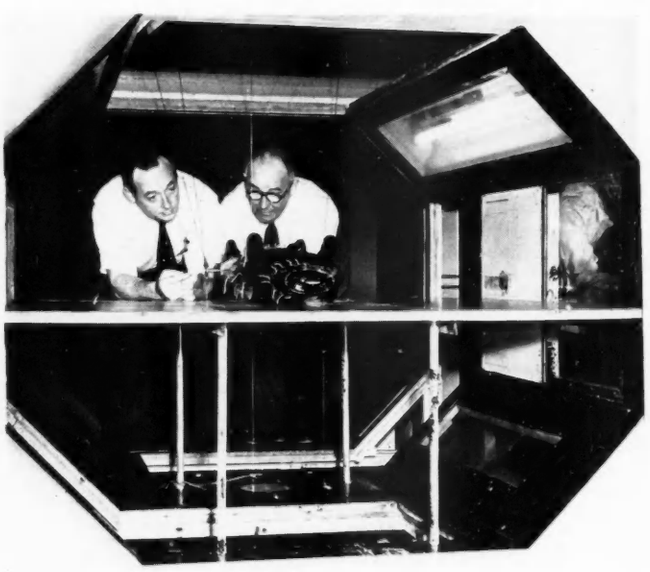
The New Bluebird Takes Shape

THE land speed record of 394·2 m.p.h. has been unchallenged since set up in 1947 by the late John Cobb. Now comes the news that Donald Campbell's Bluebird car is expected to make an attempt on it in 1960. Recently, prototype models were demonstrated at the Imperial College of Science and Technology after undergoing tests in the wind tunnel there. The design has been aimed for at least 450 m.p.h.

Probably the most highly stressed items of such a car are the tyres; therefore it is logical that the design should start with them. This part of the research has been in the hands of the Dunlop Rubber Company, and it is understood that their facilities for testing high speed tyres are being considerably extended. Heat dissipation has dictated a size of about 52 in diameter which in turn has dictated many points of body design in order to accommodate such large wheels. Their effect on the housing can be seen in the illustrations. Since the wheels will be revolving at about 3,000 r.p.m., and they will also have some vertical movement, it is important to keep the gyroscopic effect to a minimum; fully independent suspension will be used. The enormous amount of heat to be dissipated in braking has also to be allowed for to avoid any distortion of the wheels. From a speed of 500 m.p.h., about 75 million ft-lb of energy must be absorbed; this has meant a problem in air brakes too, as the mechanical disc brake cannot be brought into action until the speed has fallen below 400 m.p.h.

The design of the car is also in some measure dictated by the Utah course. This is only 11 miles long—not a great distance in which to attain a speed of 500 m.p.h. and then to brake to zero. Since two runs must be made in opposite directions to establish a record, the measured mile must necessarily be in the middle, leaving five miles for the acceleration and five for the braking. In order to utilise the weight of the car to the full, it has been decided to incorporate four-wheel drive. This decision raises the question of whether to fit a differential between front and rear axles to accommodate the difference in rolling radius that will exist between front and rear wheels during acceleration and braking, or whether to allow the shaft to take the strain by a combination of wind-up and wheel slip. It is understood that the latter solution is the one favoured. It is not intended to fit differentials on the axles themselves unless later tests show that they are necessary. This might be so with the front axle to allow for steering, though this is restricted to 5° in either direction.

The need for very accurate wind tunnel tests arises from the need to eliminate wind drag as far as possible. Not least among the aerodynamic problems is that of lift. There are the two extremes: the car could become air-borne or it could try to burrow into the ground. Both are undesirable. In the first case the load would be removed from the tyres and the wheels would slip—not to be countenanced on account of the loss of acceleration and control, and of the heat that would be generated. In the second, excessive load would burst the tyres.



Above are two of the designs tried, but the one shown in the wind tunnel was more nearly the ideal. With it are Mr. Campbell and Mr. Villa.

At Imperial College one-eighth scale models were tested in the wind tunnel at speeds up to 110 m.p.h. and from these figures the performance at 600 m.p.h. was calculated. The models were suspended from a balance and the resulting loadings measured using a flat plate mounted just below the model as the ground. Apart from comparing various car shapes, the effect of the wheel fairings, cockpit covers, tail fins and the air brake flaps have been assessed, and on one model the internal flow through the engine was simulated. Wool streamers stuck on the exterior indicated local air flow over the surface. The tests have now been concluded and the shape selected; arrangements are in hand for its manufacture.

Power for the car will be supplied by a Bristol Proteus free-turbine engine (as used in the Britannia airliner) developing over 4,000 h.p. at 11,000 r.p.m. The drive will be through reduction gears, but there will not be any clutch or change gears. This will necessitate a change in driving technique. A torque meter will enable a predetermined rate of acceleration to be followed and excessive values avoided. Alternatively, an accelerometer could be used, suitably calibrated. Control of acceleration would be by a foot operated throttle. The braking sequence would be automatic and would be initiated by pressing a button. The first stage would be the extension of the air brake flaps and then the mechanical brakes (working on discs) would come in when the speed fell below 400 m.p.h., as mentioned earlier. Even braking by both flaps and discs is of great importance. Stopping in the available five miles would represent an average deceleration of about 0·3*g*.

The leading dimensions of the design that has now been approved are: all-up weight 9,000 lb; overall length 30 ft 4 in; overall width 8 ft; overall height 4 ft 8 in; wheel diameter 4 ft 4 in; track 5 ft 6 in; and wheelbase 13 ft 6 in. The designers are Norris Brothers Limited, who were responsible for the Bluebird hydroplane.

Companies in the News

Centenary in Transatlantic Talk

Cable and Wireless have drawn attention to the fact that it was in August, 1858, that a communication link between the old world and the new was first established. At that time, messages took several minutes to be hand-tapped over the cable, whereas, to-day, modern high-speed automatic techniques have reduced this time to a few seconds. In about 1866, a network of inland telegraph lines extended throughout Britain and reached the western coasts of Ireland. Similarly, there was a network throughout the eastern states and provinces of the United States and Canada, and across Newfoundland. It was then that the idea of linking the two inland systems was born. The Atlantic Telegraph Company was formed in 1856 and decided to lay a cable from Valentia Island, County Kerry, to Trinity Bay in Newfoundland. Two ships, H.M.S. Agamemnon and the U.S. frigate Niagara combined to make the attempt.

The story of the difficulties which attended the laying, an adventure that was not completed until July, 1858, is told by Cable and Wireless in a centenary celebration message. Tremendous enthusiasm greeted the success of the enterprise and *The Times* commented that " since the discovery of Columbus, nothing has been done in any degree comparable to the vast enlargement which has thus been given to the sphere of human activity." Just the same, a few months later insulation faults developed and, by October, the cable became unusable. A second attempt to lay another cable was delayed until 1862, when the Great Eastern, a ship specially designed by Brunel, was employed. It took nine years of fruitless endeavour and bitter disappointments before a second cable spanned the Atlantic. In the 35 years that followed, a cable network was laid encirling the globe and linking all British Commonwealth countries.

Under the chairmanship of Sir John Pender—who personally guaranteed £1 million towards a further attempt after the failure of the Great Eastern in 1865—cable communications quickly prospered. Since the amalgamation of cable and wireless undertakings in 1929, a complete record of words carried has been maintained. It grew from an estimated 84 million words in 1913 to 221 million in 1930, 455 million in 1940 (cable and wireless combined) and 772 million in 1956. Of this last total, some 60 per cent was carried by wireless and 41 per cent by cable. The next move, in 1957, was the laying of a transatlantic telephonic cable, thereby opening a new era of quick and clear communications between the two continents.

Simca Sold by Ford to Chrysler

The Ford Motor Company of America have sold their minority interest in the French automobile concern Simca Société Industrielle de Méchanique et Carrosserie. The interest is being purchased by the Chrysler Corporation in the United States. Ford have held 15·2 per cent of the share capital since Ford S.A. Francaise was merged with Simca in 1954. The sale of the interest in Simca does not affect the continued operations of the company's French sales subsidiary in Paris called Ford France S.A.

It would appear that Ford's interest in the European market so far as production units are concerned is to be concentrated in this country and Germany. Both countries are at the moment undertaking expansion programmes. It has been one of the big questions arising out of the European Common Market and the possible Free Trade Area whether the large American automobile companies would concentrate their interests on certain plants, closing others down or getting rid of them where their justification has been the existence of a national market protected by tariffs. It would seem that Ford of America have made their decision and are now proceeding to carry it out.

Most of the plants owned by American companies in Europe are based on the medium and small size of car so far as motor-cars are concerned. It is by no means certain that American automobile manufacturers will be able to work out their European policy entirely in terms of the needs of European and British Commonwealth markets. There are increasing signs that the American automobile industry is going into the smaller car market and if it does the large automobile groups may wish to do some basic thinking about the future of their factories in Europe. The industry, as always, is in a state of flux. This is the way the industry had progressed in the past and no doubt the way in which it will continue to progress in the future.

Interim American Reports

The full impact of the economic storm of the past few months is being reflected in the results of leading United States and Canadian companies. Two reports which have been received, those of the Joy Manufacturing Company, one of the largest manufacturers of mechanical-handling equipment in the United States, and of the International Nickel Company of Canada, bear the marks of most severe setbacks and point to no particular hope of a speedy recovery.

Joy Manufacturing report a total loss of 551,000 dol, or 0·31 dol a share, for the three months ended June 30, as against a profit of 1·70 dol per share for the corresponding period last year. Much of this loss resulted from strikes at the company's plants at Franklin, Pa., and at St. Louis, Mo., lasting through most of April and May, but operations have resulted in a profit since work was resumed. Bookings of orders in May and June showed a moderate improvement, but Mr. W. L. Wearly, the company's president, expects further falls in output during the next few months.

International Nickel report earnings per share of 1·46 dol for the first six months of 1958, compared to 3·12 dol a share for the corresponding period last year. Deliveries of nickel during January to June were down by approximately 35 per cent, compared with January to June, 1957, and deliveries of copper and platinum were also reduced. The company's chairman, Dr. John F. Thompson, and their president, Mr. Henry I. Wingate, told shareholders that " the persistent lower level of demand and a further increase in our stocks of unsold nickel have required the company to make the third consecutive curtailment in nickel production this year, reducing the annual rate, as from the middle of July, to approximately 200 million pounds of nickel and 200 million pounds of copper." Marketing activities have been intensified, " with the aim of increasing nickel applications" in order to take advantage of what they believe will be a " continuing period of abundant supplies of nickel for the free world." On 2 July, the United States Department of Commerce announced that all American Government agencies were authorised to specify nickel " wherever it could be used advantageously." Dr. Thompson told his shareholders that " there is a firm basis for our confidence in the future," but that it would obviously take time before the current downward trends were reversed.

Perspective in Rhodesian Copper

Mr. H. F. Oppenheimer, having taken over the chairmanship of Nchanga Consolidated Copper Mines Limited on the death of his father in November last, has recently reviewed the principal items of progress during the year ended 31 March. Copper sales, he noted, totalled 121,000 long tons, a record for the company. Yet the relatively low average price, during the year, for electrolytic copper in the London Metal Exchange, £198 a long ton, more than halved the company's profits, reducing them from £9·5 million to £4·4 million.

The outlook appears to have improved, but even so, remains uncertain. During recent months, the copper price has shown a tendency to rise from the low point of £160 a ton reached in February this year. " The present position," Mr. Oppenheimer said, " as a result of the cuts in production made in various parts of the world, appears to be one of balance between supply and demand."

The Anglo-American Corporation, which, with the Rhokana and Bancroft firms, constitute the Nchanga company, decided to diminish the aggregate planned output of the group by about 10 per cent. They have achieved this reduction by closing down Bancroft, which is " a new mine, and on that account a high cost producer," for one year, as from April 1, and to increase slightly the output of the other two bodies. Mr. Oppenheimer stressed the importance of increasing efficiencies and of reducing the costs of production, in order to restore adequate profit margins. In consequence, he said, " the use of labour and of machines is being continuously and thoroughly reviewed " by the company's consulting engineers, the general manager and his staff at the mine. Improved relations between the European and African unions (a joint liaison committee has been formed) are making a significant constribution to higher productivity and, in general, the group look forward to the future with confidence. The Nchanga mines are the largest copper producers in the British Commonwealth and one of the most efficient.

Joint Venture to Rhodesia

It was announced at the beginning of this month that a joint company to be known as Brockhouse Allen Limited is to be formed in the Federation of Rhodesia and Nyasaland by J. Brockhouse and Company Limited, West Bromwich, and W. G. Allen and Sons (Tipton) Limited, Tipton. The new company is to have a capital of £200,000 of which Brockhouse will hold 60 per cent and Allen and Sons 40 per cent. Brockhouse already have a subsidiary in Rhodesia, whose works will be taken over by the new company, while J. Brockhouse (Rhodesia) Limited will continue to operate as a separate company in Southern Rhodesia, where its main activities are the production of sheet metal fabrications.

The new company will be engaged on the production of engineering requirements for the mining and transport industries and clearly their principal customers are likely to be the large copper producers. W. G. Allen and Sons already have an established connection with the copper producers and a combination of companies, whose activities have much in common, has obvious advantages in a country such as Northern Rhodesia.

The successful establishment of engineering works in countries such as Rhodesia presents many difficulties. In the first place the market is relatively small and in the second the great distances between centres of population result in high transport charges on both raw materials and finished products. In some cases small engineering concerns which established themselves in the Federation when steel was in short supply in the United Kingdom have found that it is now more economic to produce in the United Kingdom and ship the product to Rhodesia. Another difficulty encountered is that of maintaining plant and machinery and obtaining spare parts.

For many engineering products, however, the Northern Rhodesian copper producers provide a concentrated market and thus a nucleus on which future expansion can take place. The expansion of the Rhodesian iron and steel industry at Que Que will ensure adequate supplies of steel and is also expected to reduce costs, though heavy freight charges will be involved in transport to the copper belt.

Atomic Review

Contracting Parties

In the three years that have elapsed since the first International Conference on the Peaceful Uses of Atomic Energy, nuclear activities have passed from being largely the concern of research bodies into the area of commercial enterprise. The following notes consider some of the work of major British contractors in the nuclear field.

Young Consortium

Atomic Power Constructions Limited are supported by a consortium of six companies. The chairman, Lord Coleraine, has recently stated that the group is constituted rather differently from the other consortia. He pointed out that nuclear engineering involves the synthesis of many aspects of engineering and that the problems that arise are of such technical complexity that no independent decisions can be taken in a particular field without affecting decisions in other, apparently remote, fields.

"These circumstances," said Lord Coleraine, "require the closest liaison between engineers concerned with different aspects of the work. To facilitate this and to avoid any latent unbalance in the design effort it is desirable, in our view, that there should be a central design organisation, both financially and administratively distinct from the member companies, which possesses ultimate authority for determining the design. Further, in a rapidly advancing branch of technology, design and research go hand in hand. It is desirable, therefore, that basic research facilities should come directly under the control of the central design organisation; in this way the design engineers can feel confident that the experimental programme is planned to answer the right questions, and will produce the necessary information on time. Although this may appear no great problem it is, in fact, greater than many would suppose. Though there is evidence that certain of the other groups may be moving towards the same type of organisation, Atomic Power Constructions Limited may fairly claim to be unique in the British nuclear power industry in possessing the form outlined above."

The company's research laboratories have been growing up over the past year in a hangar at Heston. A view of a pressurised carbon-dioxide rig there is shown in Fig. 1. Also illustrated (Fig. 2) is an experimental helical finned can for an atomic fuel element. It is made of magnesium and fitted with splitters attached by a patented method of one of the group's member companies—Fairey Aviation Company Limited. Other companies forming the group are Crompton Parkinson Limited, Elliott Brothers (London) Limited, International Combustion (Holdings) Limited, Nuclear Civil Constructors (Trollope and Colls Limited, and Holland & Hannen and Cubitts Limited), and Richardsons, Westgarth and Company Limited.

The group are taking part in the industrial "Atoms for Peace" exhibition in Geneva next September, where their stand will be second in size only to that of the UKAEA, in the British Section. Among the exhibits will be a model of a typical 500 MW station, and a bladed rotor of a research model blower used for developing the compressors of carbon dioxide circuits for reactors. A drawing office is to be included in the stand, complete with drawings of a power station for technical discussion.

Nuclear Components by de Havilland

Reference to the nuclear work of the de Havilland Engine Company Limited, and in particular to the company's interest in the high-temperature gas-cooled reactor was made in Atomic Review last 28 February and 7 March. The second article discussed a de Havilland loop for in-pile testing of reactor components. As an associated aspect of loop construction, the de Havilland Engine Company have developed certain items of equipment as standard commercial products. Typical of these are small high-speed gas circulators, one of which is illustrated in Figs. 3 and 4, incorporating self-acting gas bearings which obviate the need for lubrication and routine maintenance. Experimental investigations are being carried out to determine the behaviour of these bearings under simulated operating conditions and to provide data on the more suitable materials for their construction.

A variety of small valves is also being developed to meet the exacting requirements specified for radioactive gas circuits. External leakage is minimised by extensive welded and brazed joints, and internal leakage is prevented by careful attention to detail design. Extended rig testing is being performed.

Impermeable Graphite Developed by G.E.C.

Graphite which is impermeable to gases and highly resistant to gaseous corrosion has been developed for nuclear applications by the research laboratories of the General Electric Company Limited. It will be demonstrated for the first time at the 1958 Atoms for Peace Exhibition which opens in Geneva on 1 September. A graphite tube, at a temperature of nearly 600° C, will be charged inside with carbon dioxide at a pressure of ten atmospheres while a vacuum is maintained at the outer surface.

Graphite as used to slow down the fast neutrons in a nuclear reactor is a porous material permeable to gases. The graphite manufacturer relies on this permeability to prevent the disruption of his product during the intensive heat treatments associated with the standard graphite making process. Some reactor-grade graphites undergo an impregnation treatment which increases the final density but this does not effectively reduce the porosity. Permeable graphite has several practical disadvantages. In the first place, corrosion by hot gases can occur within the body of the graphite moderator blocks and is not confined to their geometrical surface. In fact, every gram of graphite exposes nearly half a square metre of surface and in a reactor containing 1,000 tons of graphite this surface is of considerable importance. Secondly, the permeability of the graphite permits the escape of gas from the coolant channels in the reactor. An impermeable graphite would permit a design in which the fission products are continuously pumped from the fuel contained within an impervious graphite tube and the coolant gas (outside this tube) remains uncontaminated. This arrangement has very appreciable advantages.

A completely impermeable graphite could have quite novel applications in reactor technology, and could also prove attractive for use in carbon dioxide, water, sodium and hydrogen-cooled reactors. For example, it might be possible to take advantage of the low neutron absorption and extreme heat resistance of graphite and use it as a canning material in place of magnox, beryllium or stainless steel. The brittle nature of graphite could well be a limiting factor, but current research work by G.E.C. is exploring the mechanical properties of graphites under nuclear irradiation and it may be that this problem will not be as serious as at first thought.

The G.E.C. research laboratories have undertaken two development programmes in this field; one to reduce the permeability of existing moderator graphites by an impregnation process, and the other to manufacture a completely impermeable material. In the latter case it has been found necessary to abandon the existing process for making graphites and the carbon atoms are built up in an entirely novel fashion. The first process has resulted in considerable reductions of the permeability of existing graphites and a millionfold improvement has been found possible. In spite of this improvement, however, gas can still enter the interior of this graphite. The totally impermeable material, on the other hand, behaves like a metal and has a gas displacement corresponding to the geometrical volume of the specimen, that is gas does not have access to the interior.

The demonstration at Geneva will show a tubular graphite element which is heated by the passage of an electric current. The temperature will be maintained at slightly below 600° C so that the tube will be just visibly red hot. The interior of the specimen is pressurised with carbon dioxide. Research work has shown that graphite does not corrode under these conditions. Since corrosion would rapidly increase the permeability, a demonstration that the impermeable nature is preserved is also a convincing proof of corrosion resistance. To illustrate the low permeability, the specimen will be mounted in an evacuated container and the rate of flow through the pump will be monitored. The pressure inside and outside the specimen are shown on the appropriate gauges. Most applications of a totally impermeable graphite call for a method of welding or joining graphite to graphite, or graphite to metals. The exhibit will demonstrate such a joint operating under stress at reactor temperatures and, at the same time, acting as an impermeable barrier to the carbon dioxide gas.

Sea Highway

Having now successfully launched and delivered three of the twelve heat exchangers for the Bradwell nuclear power station, Head, Wrightson and Company Limited have published a booklet,

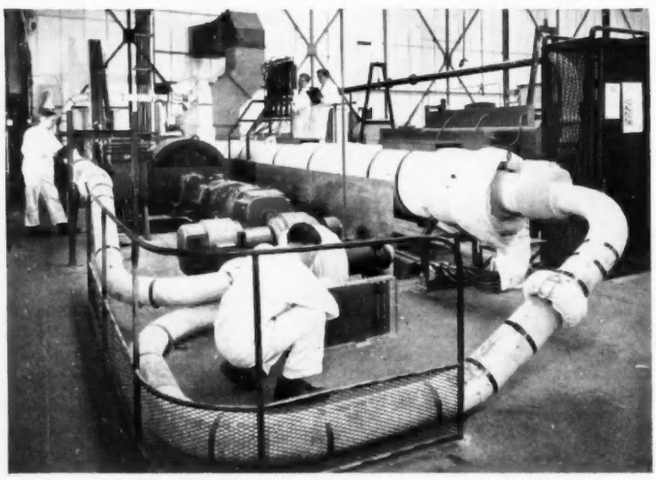


Fig. 1 (left) A pressurised carbon dioxide fuel element test rig has recently been put into operation at the research and development laboratories of Atomic Power Constructions Limited.

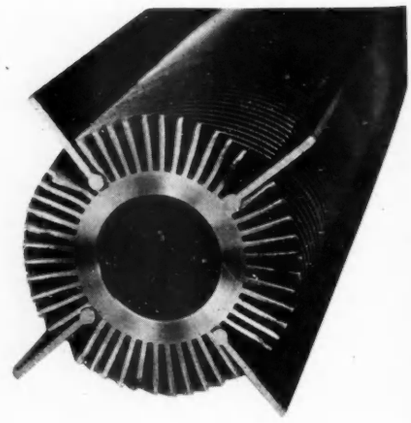


Fig. 2 (right) An experimental helical finned can for an atomic fuel element. It is made of magnesium and fitted with splitters.

Sea Highway, which has been prepared to commemorate the unusual method of transporting these heat exchangers.

Joint Nuclear Handling Company

A jointly-owned British-American company concerned with designing and marketing remotely-controlled handling equipment for handling radioactive materials in nuclear establishments is being established. The new firm will supply mechanical and powered manipulators, reactor fuel loading and unloading systems, reactor maintenance systems, and other remote handling apparatus and ancillary protective equipment. The British partner is Savage and Parsons Limited (Watford, Hertfordshire) who have been concerned with the design and manufacture of this kind of equipment since 1954. Their mechanical "Master Slave" manipulators, remote handling tools, lead shielding bricks, and other equipment are used in establishments of the United Kingdom Atomic Energy Authority. There is also a considerable export business to nuclear establishments throughout the British Commonwealth, Norway, Sweden, Holland, Germany, Denmark and Japan. The second partner is the Mechanical Division of General Mills, Inc. (Central Avenue, Minneapolis 13, Minnesota, U.S.A.), who have been responsible for the design and manufacture of heavy-duty manipulators and reactor fuel charging systems since 1948. Their nuclear equipment department, a specialised unit of the Mechanical Division, designs and supplies many types of remote handling devices to the United States nuclear industry.

Emergency Generators for Chapel Cross

Eight Crossley 500 kW diesel engined automatic standby generator sets are installed at the United Kingdom Atomic Energy Authority's nuclear power station at Chapel Cross.

There are four separate engine-rooms, one per reactor, each housing two sets. The engines are Crossley HSN six-cylinder two-stroke scavenge pump diesels, with a bore of 10·5 in (267 mm) and a 13·5 in (343 mm) stroke, each developing 800 b.h.p. at 600 r.p.m. and direct coupled to a Brush 240 V direct current generator. The sets are fitted with electro-pneumatic starting gear which automatically puts the engines into action on failure of the mains supply, and are capable of running up to normal speed and taking the rated load within five seconds.

The compressed air starting pressure is 250 lb per sq. in and air is stored in receivers which are re-charged by a motor driven air compressor which is also arranged for automatic starting when the air pressure falls below a predetermined figure. A selector switch enables the engines to be run either singly or in pairs, according to the requirements of the station.

Steel Fans

A contract for a total of 12 steel industrial fans, the two largest weighing 2½ tons each and standing nearly 9 ft high, has been placed for the Atomic Energy Authority and Spadeadam Rocket Research Establishment, with the Airscrew Company and Jicwood Limited, of Weybridge, Surrey. Two input fans handling air volumes totalling 17,450 cu. ft per min ordered for the United Kingdom Atomic Energy Authority will be used in a laboratory plenum system working in conjunction with a 17,450 cu. ft per min fan extracting from fume cupboards. The Airscrew Company has already supplied laminated wooden impellers for use in cooling towers at Calder Hall.

Power Stations and Plutonium

In the House of Commons last week Mr. Green asked the Paymaster General to what extent British nuclear power stations were currently being modified so that military grade plutonium could be extracted; what effect such modification was expected to have on the economics of nuclear power operation and the sale of British nuclear equipment abroad; and whether he would make a statement. The Paymaster General, Mr. Reginald Maudling, replied: "Three nuclear power stations are being modified, but whether they will ever be used to produce military grade plutonium will be for decision later and will depend on defence requirements. The first two stations, at Bradwell and Berkeley, are not being modified and the decision to modify three subsequent stations was taken solely as a precaution for defence purposes. It in no way reflects any change in the assessment of the economics of the British nuclear power stations, and there is therefore no reason whatever why the sale abroad of British nuclear equipment should be in any way affected."

C.E.G.B. Health Officer

Mr. C. A. Adams, chief of trials and safety of the United Kingdom Atomic Energy Authority Weapons Group established at Aldermaston, has been appointed chief nuclear health and safety officer of the Central Electricity Generating Board.

Computer for Belgian Nuclear Centre

A British electronic computer claimed to be the most advanced in scope and speed yet produced in Western Europe, has been ordered by the Belgian Atomic Energy Authority. The machine is the high-speed Mercury electronic digital computer made by Ferranti Limited. The Belgian order represents the seventh European atomic centre to employ this computer, the others being at Geneva, Paris, Oslo, Stockholm and the United Kingdom establishments at Harwell and Risley. The computers are employed in such calculations as those involved in the design of power reactors.

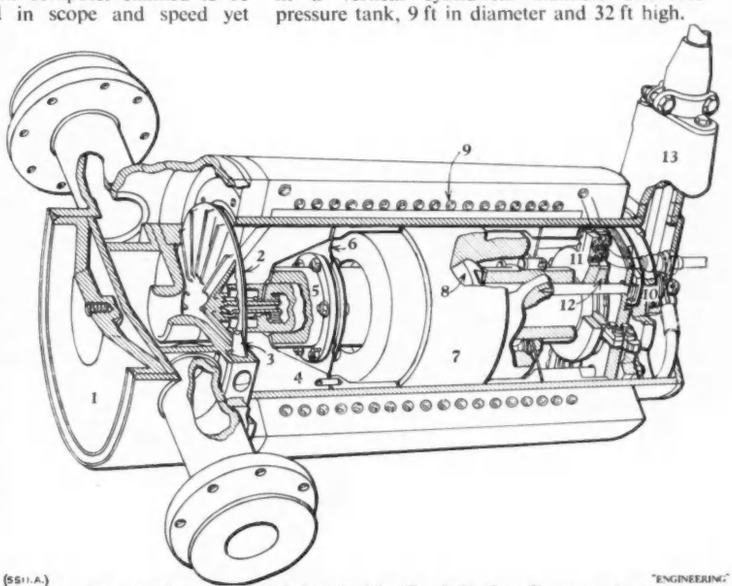
Operator for N.S. Savannah

A proposal by States Marine Lines to serve as general operating agent for the N.S. Savannah has been selected as the basis for the negotiation of a contract, the Maritime Administration, U.S. Department of Commerce, and Atomic Energy Commission have announced. The Matson Navigation Company will act with States Marine Lines in the handling of passenger travel. The schedule of proposed operation of the N.S. Savannah, after her delivery early in 1960, is in three phases: phase one, initial trials and tests—six months to a year; phase two, national and international operation in modified commercial service for operational evaluation purposes; phase three, commercial operation in passenger-cargo services.

The keel of the N.S. Savannah was laid on 23 May 1958. Launching is scheduled for 1959. The ship will be a combination passenger-cargo vessel, 595½ ft long, with 78 ft beam, capable of carrying more than 60 passengers and 9,500 tons of cargo at a speed of 20¼ knots, and designed to operate over three years on its initial fuel loading. The ship's propulsion plant will include a pressurised-water reactor of advanced design. Total cost of the ship and reactor will be about 31 million dol.

NACA Reactor Permit

The United States Atomic Energy Commission have issued a construction permit to the National Advisory Committee for Aeronautics for a research and testing reactor to be built at the Plum Brook Ordnance Works near Sandusky, Ohio. Cost of the 60 MW (heat) reactor, to be used by NACA to further development of reactors suitable for aircraft propulsion, is estimated at 10,735,000 dol. The NACA schedule calls for completion of the facility by January 1, 1960. The reactor is to be cooled and moderated by light water and will be located in a vertical cylindrical stainless steel-clad pressure tank, 9 ft in diameter and 32 ft high.



(S511.A.) "ENGINEERING"

Fig. 3 Gas circulator designed by de Havilland Engine Company to pump gas in radioactive circuits at pressures up to 20 atmospheres and temperatures up to 350° C. The motor and bearing assemblies are cooled by water circulating in an external coil which is Alfin bonded to the steel pressure casing.

1. All-welded steel casing
2. High-pressure low-volume flow impeller
3. Pitot-type diffusers
4. Copper heat conductor
5. Self-acting gas journal bearings
6. Self-aligning diaphragm mounting
7. High-frequency induction motor (400 c/s)
8. Shrunk-on rotor
9. Aluminium-bonded water-cooling coils
10. Sealed connections
11. Self-aligning gas-bearing thrust plate
12. Rotating thrust plate
13. Terminal box.

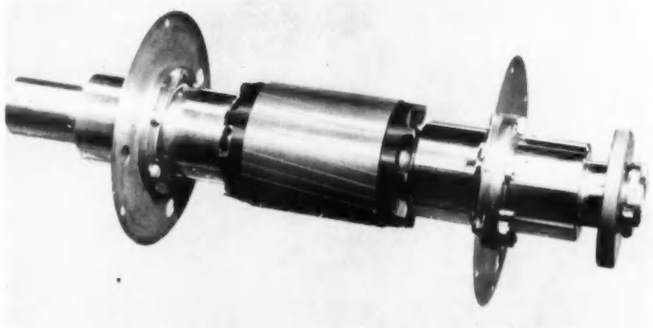


Fig. 4 Rotating assembly of de Havilland gas circulator, showing self-acting gas journal bearings located in diaphragms. The end load of the assembly is taken on a viscosity-type gas bearing mounted on a universal gymbal.

Stresses in Spherical Pressure Vessels

In a paper presented to the Institution of Mechanical Engineers, entitled "Theoretical Analysis of the Stresses Induced in a Spherical Pressure Vessel due to the Constraining Effect

Continuing Atomic Review

of a Cylindrical Skirt," Dr. Raymond Hicks has put forward a method of analysis for the bending moments and shear forces in large pressure vessels which he suggests justifies the use of Heténi's approximate solution and the assumption that the effective skirt length may be taken as infinite. Expressions are obtained for the induced stresses when (1) the vessel is stressed by a uniform radial pressure and (2) the skirts are loaded in an axial direction. In an appendix to the paper the general solution is used to consider briefly the particular problems of (*a*) temperature gradient in the bottom skirt; (*b*) self weight of the vessel; and (*c*) axial load on the vessel. It is intended to publish later a further paper providing a series of graphs which will enable the designer to determine immediately the moments and shear forces induced in spherical vessels and cylindrical skirts having practical dimensions for the special conditions (1) and (2) above.

Shippingport and Yankee

Although the Shippingport and Yankee Atomic Electric pressurised-water nuclear power stations are not strictly comparable, a table of the principal differences may be of interest. Such a table has been published in the *Westinghouse Engineer* and is reproduced below. The Shippingport plant was fully described in Atomic Review last 30 May and the Yankee station last 27 June.

Comparison of Shippingport and Yankee Atomic Electric Nuclear Power Stations

—	Yankee	Shippingport
Core design	Uniform loading	Seed and blanket
Fuel	Low enrichment UO_2 pellets	UO_2 pellets in blanket U_{235} plates in seed
Fuel cladding	Stainless steel	Zirconium
Control rods	Silver-indium-cadmium	Hafnium
Cold shut-down control	Control rods plus chemical	Control rods
Vapour containment	Monocellular, above ground	Four connected cells, partially below ground
Remotely operated valves	Electrically operated	Hydraulically operated
Instrumentation	Minimum consistent with power generation requirements	Consistent with both experimental and power generation requirements
Fuel storage	Simplified pit	Canal consistent with experimental requirements
Waste disposal	Simplified to suit power requirements	Capacity to suit experimental requirements of plant

Microtron

The microtron that has been under construction at University College, London, is now accelerating electrons to energies of 29 MeV. Included in the experimental programme are the study of bremsstrahlung spectra and the determination of the rate of energy loss of electrons in various materials. The present electron energy achieved is slightly greater than the design figure and further increases are expected, as the electromagnet, whose 80 in diameter poles form the top and bottom of the vacuum chamber, was designed to run at higher fields than those at present used (about 1,000 oersted).

The machine operates in the fundamental mode with a pulsed radio frequency supply of 1 MW peak. This operates at 3,000 Mc/s. In the 57th, and final, orbit the current is 10^{-9} A average —a figure that is likely to be increased.

Pocket Radiation Monitor

Philips Electrical Limited announce a new transistorised pocket radiation monitor (Type PW4014), which employs printed wiring. It is a watertight, fully tropicalised instrument of rugged construction designed for the general survey, location and measurement of radioactivity. It weighs only 1 lb 5 oz and its small dimensions—$6\frac{1}{8} \times 4 \times 1\frac{3}{8}$ in—enable it to be carried easily in the pocket. A built-in Geiger-Muller tube permits the instrument to be used as a probe for measuring gamma radiation and a separate mica end-window Geiger-Muller tube with a flexible lead can be plugged into the instrument for beta measurements.

Two measuring ranges are incorporated: one for high and the other for low sensitivity. An accurately balanced easily read meter, calibrated in mr/h (milliröntgens per hour) indicates the radiation intensity. A small earphone can be connected for the audible detection of very low intensities. The power supply is a 3 V flashlight battery or two miniature 1·5 V cells. The all-transistorised circuit has a low drain, so that long battery life is assured.

This monitor is suitable for use in all cases where the indication and measurement of radioactivity is necessary or desirable. Typical applications are for geological surveying, location of missing radioactive material, checking of radioactive contamination, dose rate measurements involving personnel, intensity measurements in laboratories where there is a radiation hazard, and monitoring of special tracer experiments. The price is £47 10s. (basic). Accessories are extra and include G-M probe for beta radiation measurement £11, and earphone £3.

Hand and Clothing Monitor

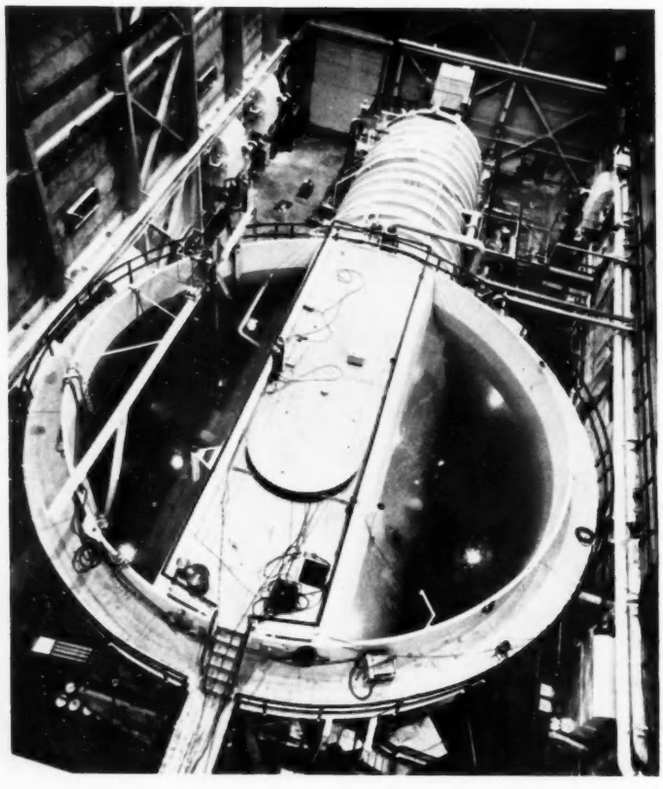
A new monitor designed to safeguard those engaged in work which may expose them to atomic radiation hazards has been developed by E.M.I. Electronics Limited. Known as the Hand and Clothing Monitor Type 1, the instrument has many outstanding advantages over any similar equipment at present commercially available.

Four large area scintillation counters with special dual scintillators are used simultaneously to detect both alpha and beta contamination on the hands. Separate meter indications are provided and a unique feature is that the final meter readings remain after the hands have been removed. These readings are cancelled when the next person begins testing.

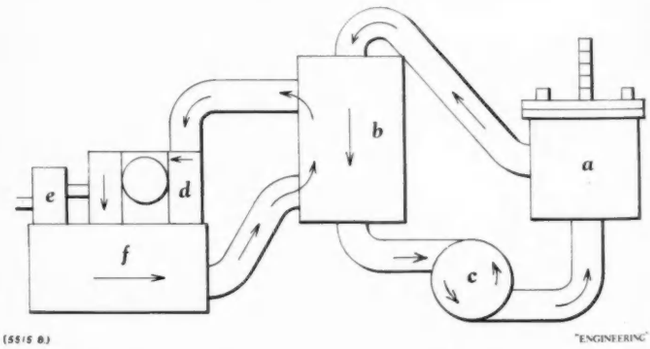
Audible and visible danger level warnings are given should the user be contaminated in excess of the maximum permissible level. Background gamma radiation up to a level of 0·5 milliröntgens per hour is automatically cancelled during the operating period which can be as short as five seconds.

The two probes attached to the sides of the main cabinet which provide separate indications of both alpha- and beta-gamma levels, are used to measure radiation from clothing and footwear. As these probes may be used at the same time as the special hand counters it is possible to monitor or process three people simultaneously, thus greatly increasing the rate at which personnel can be checked for contamination.

POWER PLANT FOR THE SUBMARINE NAUTILUS



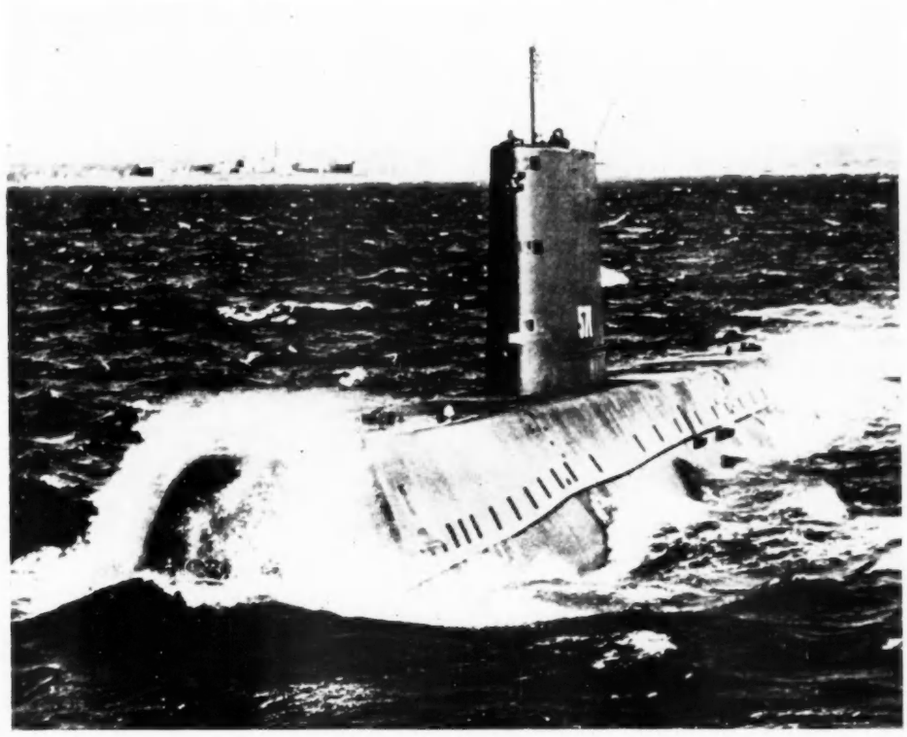
(*Left*) *Land-based prototype of the reactor used in the propulsion plant of the United States submarine Nautilus. The reactor is of pressurised-water design.*



(*Above*) *Power plant of the Nautilus shown diagrammatically.*
(*a*) Reactor.
(*b*) Boiler.
(*c*) Circulating pump.
(*d*) Turbine.
(*e*) Reduction gear.
(*f*) Condenser.

BY WAY OF THE NORTH POLE

U.S.S. Nautilus Demonstrates New Prospects for Nuclear Propulsion



The route taken by the nuclear-powered submarine Nautilus beneath the Arctic ice cap has cut the distance between Tokyo and London by roughly half.

THE dramatic exploit of the submarine Nautilus has created widespread comment, and revealed unforeseen prospects for commercial shipping. The use of nuclear-powered submarines for trans-polar runs between Tokyo and London is no doubt still far off, but it may be of interest to put on record the details of the Nautilus's voyage.

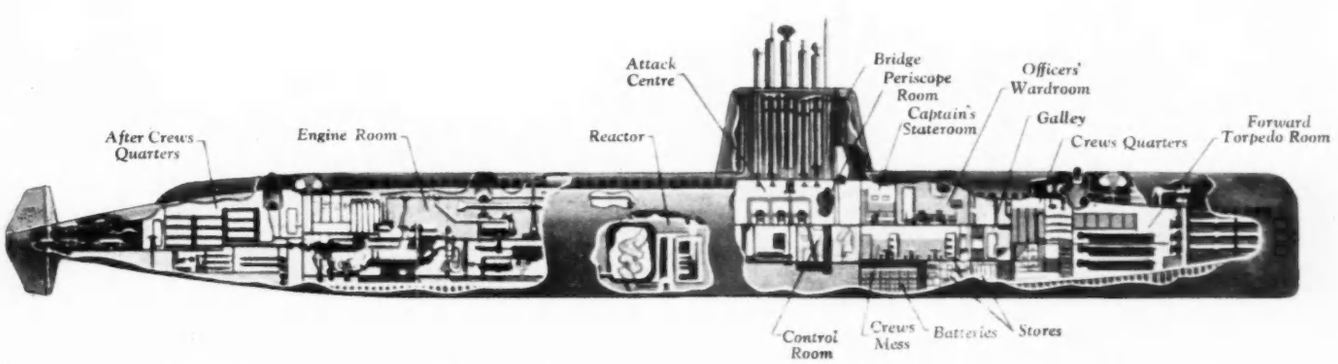
The United States nuclear-powered submarine Nautilus has completed a journey from Pearl Harbour, Hawaii (23 July), by way of the Bering Strait (29 July) and the North Pole (4 August), to Iceland (8 August), passing under the Arctic ice cap. (See Leader this week.) With a crew of 116 men and captained by Commander W. R. Anderson, the Nautilus was submerged for 96 or 97 per cent of the time during the 16-day journey. The submarine was under the ice pack for 96 hours, covering a distance of 1,830 miles and travelling at a depth of 400 ft or more and a speed of about 20 knots. The complete journey to Portland from Honolulu is some 8,150 miles, taking 19 days. She went under the ice pack near Point Barrow, on the north coast of Alaska, and found a " deep sea valley " ranging in depth from 30 ft to 1,200 ft, which was followed until the Arctic Sea basin was reached. Under the North Pole, the depth of water was found to be 13,400 ft—nearly 2,000 ft more than had been expected.

Tributes have been paid to the navigational achievement of the Nautilus; for the hazards involved around the North Pole, the crew coined the expression " longitude roulette." The navigational principle employed was that of inertial guidance, in which gyroscopes and accelerometers are used to determine changes in attitude and speed. A computer processes this data to calculate the path followed from the point of departure.

The commercial significance of the voyage, particularly in view of the advantages claimed for long-distance cargo-carrying submarines (see ENGINEERING, 13 December, 1957, page 738), is underlined by the White House statement that the journey of 11,200 miles from London to Tokyo by present routes could be reduced to 6,300 miles by a sub-Arctic route. A proposal has been made that trans-Polar submarine tug trains might provide a regular service, and it is significant that a nuclear-powered submarine with twice the running costs of a conventional vessel might still be economic. The Nautilus was refuelled in spring, 1957, after travelling some 60,000 miles on a single fuel charge (Atomic Review, 25 Jan. '57). The reactor, which is of pressurised-water design, is cooled and moderated by ordinary (light) water and employs enriched uranium as fuel. The power plant serves not only for propulsion but also supplies auxiliary services such as lighting, communication, air-conditioning and refrigeration.

Nautilus has previously been mentioned in Atomic Review on 24 August, 1956 (page 252); 18 January (page 93), 25 January (page 123), and 1 November (page 571), 1957; and 3 January, 1958 (page 14). She was built by the Electric Boat Division of the General Dynamics Corporation and was commissioned on 30 September, 1954. The reactor was made by the Westinghouse Electric Corporation (working under contract for the United States Atomic Energy Commission) and the first time Nautilus was propelled solely by nuclear power was on 17 January, 1955. Her displacement is 2,975 tons; her length, 323 ft; beam, 28 ft. The estimated cost of the vessel, excluding the reactor, is 29 million dol.

The Nautilus docked at Portland, England, last Tuesday (12 August), when the crew were met by the United States Ambassador, John Hay Whitney and the First Lord of the Admiralty, Lord Selkirk.



Layout of the interior of the Nautilus showing the location of the nuclear propulsion unit within the hull.

Special Article

INDIA'S IRON AND STEEL INDUSTRY GROWS

U.K. Contributions in Plant and Technical Skill

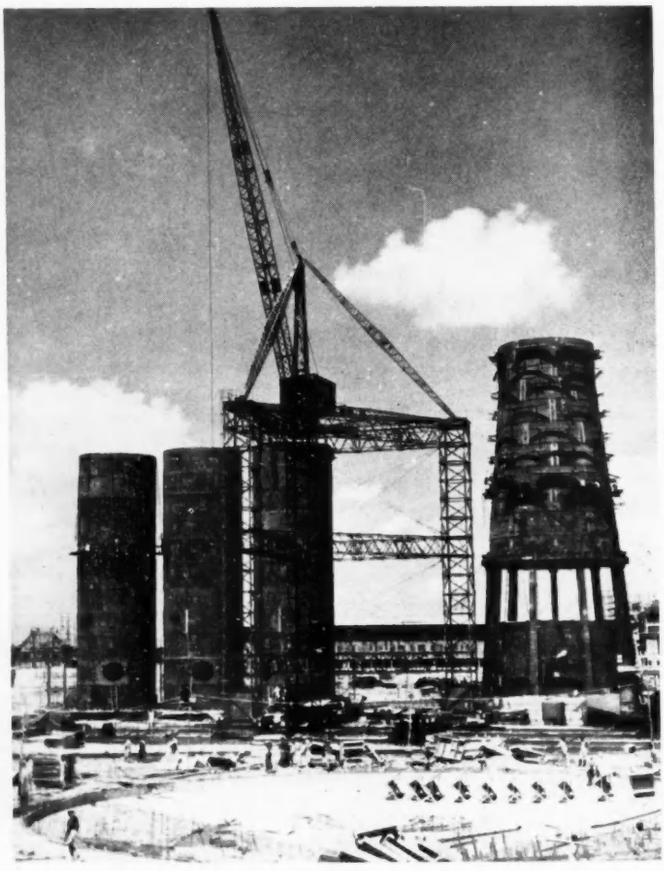
Under the Colombo Plan the United Kingdom is participating in the international scheme, authorised by the Government of India, to train the men who will be the managers, foremen, and key operating personnel of the new Government-owned steelworks now under construction in India.

India's second five-year plan provides for approximately doubling the capacity of its two largest steelworks, those of the Tata Iron and Steel Company and the Indian Iron and Steel Company, and the building of three new works, each with a rated capacity of approximately 1 million tons of steel ingots a year. This will provide India with a total annual output of about 6 million tons of steel by 1962, a four-fold increase in steel output compared with 1955.

Britain, West Germany and Russia are each building one of the new steel works. The site for the Russian-built plant is at Bhilai in the Central Provinces (Madhya-Pradesh), the German-built works are at Rourkela on the border of the Central Provinces and Orissa, and the plant being constructed by British contractors is at Durgapur in West Bengal, 118 miles from Calcutta. The whole development project is being handled by the Hindustan Steel Company on behalf of the Indian Government.

The contracting arrangements on each of these three sites are somewhat different. The German participation in the development scheme dates bach to 1953 when the Krupp-Demag group undertook to act as consultants for the Rourkela plant for the production, primarily, of flat products; the Hindustan Steel Company was initially formed by the Indian Government to be responsible for the project and the placing of contracts with the thirty or so firms for site development, plant manufacture and construction.

For the second plant at Bhilai, for the production of structural steel, the equipment is being supplied by the Soviet Union and the site development and erection of the plant has been undertaken by Hindustan Steel with the assistance of Russian engineers and technicians. At Durgapur, a fully-integrated steelworks is being built by a group of British companies, as a packaged deal, and will include coking, iron, steel and by-products plants, foundries, rolling mills, engineering workshops, power plant, transport, offices and all other plant facilities. Railway sidings, central power supplies and the building of a new town for 25,000 people, where formerly there was a small village in scrub jungle, will be the responsibility of the Indian Government. At present, about 120 Europeans are employed on the site, although another 250 are probably employed on construction work outside, and more will be required during the operation period. Special accommodation and offices have been built by the contractors for this personnel and their families. Indian labour is used for the civil engineering and construction work and altogether about 14,000 persons are employed.



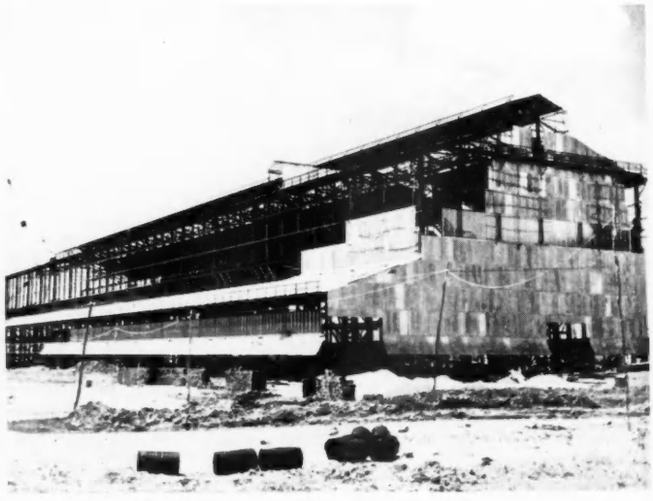
(Left) Progress on site of the Durgapur steelworks in West Bengal, India. First blast furnace, 27 ft hearth diameter, and stoves with foundation for thickener tank in the foreground.

(Below left) Second coke-oven battery in course of erection.

(Below right) Cladding of the steel-framed special casting shop. Cladding at the base is bent outwards to provide additional ventilation.

BRITISH CONSORTIUM (ISCON)

A consortium of 13 leading British engineering and electrical manufacturing companies—the Indian Steelworks Construction Company (ISCON)—has been formed to build the Durgapur steelworks. The companies in the consortium and the contract work for which they will be responsible, are as follows: Cementation—civil engineering except coke ovens and power plant; Dorman Long (Bridge and Engineering), Cleveland Bridge and Engineering, and Joseph Parks and Son—structural steel; Sir William Arrol—cranes and structural steel; Head, Wrightson—blast furnaces and iron-



making plant; Davy and United—rolling mills, wheel tyre and axle plant, the foundry, and the central engineering maintenance shop; Wellman Smith Owen Engineering—open hearth furnaces and steel-making plant, cranes, and soaking pits; Simon-Carves—coke ovens and by-products, power plant, and steam and gas distribution; British Thomson-Houston, English Electric, General Electric and Metropolitan-Vickers Export—electrical work.

The contract covers an expenditure of about £100 million, of which over £50 million will be for plant production in the United Kingdom, and about £50 million for construction work in India. For the Durgapur project the British Government has loaned the Indian Government £15 million, plus a letter of credit for £11½ million arranged by Lazards from the Lloyds, Barclays, Martins, Glyn Mills and District banks.

Work on the site for the Durgapur plant began in November, 1956, immediately after the contract had been signed. This was some months after work had commenced at the Rourkela and Bhilai sites. Mr. W. S. Hindson, managing director (formerly chief engineer) of ISCON, reported on returning from India on 27 July that work was proceeding to schedule. It is expected that the first stage will have been completed by the end of October, 1959, when the first coke-oven battery, blast furnace, foundry, pattern shop and central engineering maintenance shop will come into operation. It is planned to bring the second blast furnace and coke-oven plant into operation by the end of April, 1960, and by the same time three open hearth furnaces, 42 in blooming mill, continuous billet mill, sleeper bar plant and oxygen plant will also have been completed. A third blast furnace and coke-oven battery with the remaining four open hearth furnaces, as well as a 24 in medium section and continuous merchant mill should be completed by April of the following year. The plant should be in full operation by the end of July, 1961, when the remainder of the steel melting shop, special casting shop, and the wheel, tyre and axle plant will be ready.

The Tata Steel Company of India is already operating one of the largest and most up-to-date steelworks in the world, and electric furnace melting of steel is common practice in a number of other smaller steelworks. The immediate demand is for more blast furnace pig iron and the Durgapur plant will provide 360,000 tons of pig iron per year, while the provisional output from the rolling mill, and railway wheel, and axle plant will be 790,000 tons of steel.

INDIANS IN BRITAIN

The rapid expansion of India's steel industry raises the acute problem of training managers, foremen and key operating and maintenance personnel for the new plant. Each of the countries who have signed contracts with the Indian Government for the building of these works are providing prolonged training courses to meet these requirements and in this, as indeed in the actual plant construction, there is a certain amount of international rivalry as to who can make the best contribution.

Each of the three new steelworks will employ about 10,000, and the total number of future management and other key operative trainees involved is about 2,000. Russia will take about 700, Germany 220, and Great Britain 300. The United States has also undertaken to train about 200 personnel as a general contribution to the Indian steel industry's total requirements, although this number will probably be increased to around 600.

The British contribution, that is, the training of about 300 managers, foremen and key operating personnel for the Durgapur steelworks, is a joint effort under the Colombo Plan involving the British Commonwealth Office, the British Iron and Steel Federation and the British consortium, ISCON. The Indian Government select suitable men for this training; most of them are young graduates in mechanical, electrical, chemical and metallurgical engineering from Indian universities and other industries, and few of them, except one or two senior managers, have had any lengthy experience of the steel industry.

At present there are 68 trainees in the country, and the full period of training lasts about a year. A further group of 25 trainees arrive in November. A considerable amount of planning is involved since the course is designed to provide the individual with the greatest amount of practical experience in the type of work he will be responsible for at Durgapur. For the first six months the trainee is attached to a company where he can obtain general practical experience in a particular field such as blast furnace operation, steel melting, coke ovens, etc. The second six months is spent on specialised work, usually with a manufacturing company supplying plant and equipment to steelworks. In this way a future operative or maintenance foreman can obtain detailed knowledge about the construction and maintenance of the plant and equipment for which he will be responsible. He will also be able on his return to India to help in the installation of the plant he will ultimately operate or maintain. In addition, all the trainees are given some insight into the problems of supervision by attending, when opportune, foremen's courses, and by working with existing foremen and managers towards the end of the training.

BISF TRAINING COURSE

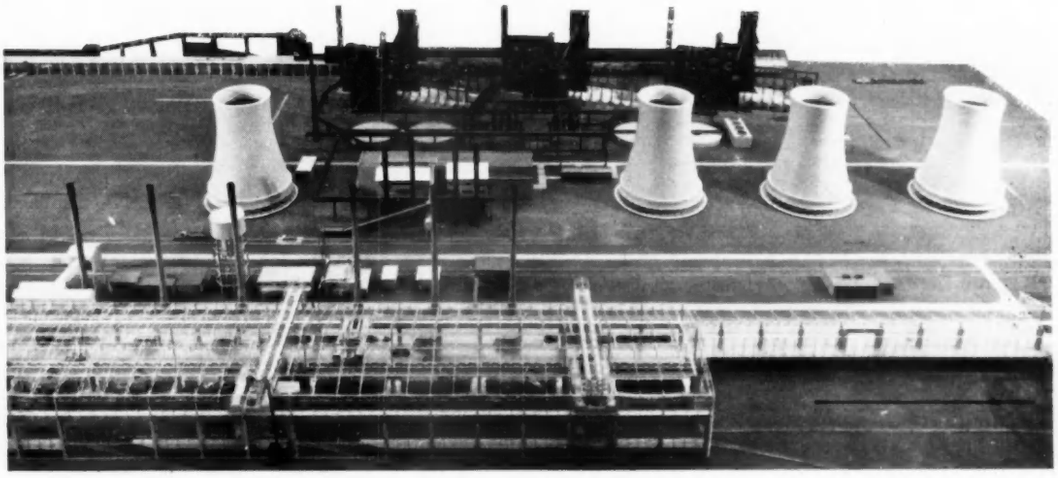
One of the important tasks facing these trainees on their return to India, will be to assist in the training of their own labour force. With this in mind, the Training Committee of the British Iron and Steel Federation have arranged for the trainees to attend a training course at Ashorne Hill, Warwickshire. At Durgapur specialists will be responsible for the training of craftsmen and operatives but it is known from experience in this country that no effective training can be carried out without the active co-operation of line management at all levels. The Ashorne Hill course is therefore designed to introduce to potential Durgapur plant management some of the methods and tools used in training, in particular, the training of craftsmen and operatives.

The chairman for the course was Mr. F. C. Hayes, technical education officer BISF, and the speakers included Mr. A. W. W. Watson, head of labour and training department, BISF; Mr. W. W. Larke, general manager, Stewarts and Lloyds Limited; Mr. P. Morris, Commonwealth Relations Office, and the various BISF area training officers. Typical subjects were: job analysis and techniques of instruction, training in manual skills, accident prevention, learning and learning patterns, manning charts, and visual aids and publications.

A tribute is due not only to the planners and organisers, but to the co-operative effort of the steel companies and plant manufacturers—not forgetting the generous attitude of the trade unions concerned—in providing the first-hand practical plant operating and manufacturing experience so valuable to the success of a new industrial venture such as the Durgapur project.

There have been those who have suggested that we may be "cutting our own throats" as regards our export trade in pig iron and fabricated mild steel. This may well be so for a time, while India's industrial development gets under way. But this development, in turn, will provide a market for special steels and non-ferrous metals, components, machinery, tools, electrical and electronic equipment of all kinds, which will probably provide the most profitable forms of future exports for this country. Hence the international keenness to secure contracts of this type, and to participate in the training of India's future steelworks managers—for they are also our future potential customers in the world market.

Indian technicians for the Durgapur steel plant are being trained in British steelworks by a scheme arranged under the Colombo Plan.



Model of Durgapur steelworks being built by the British consortium ISCON, on show at the Brussels International Exhibition. The iron-making plant, power plant and part of the steel-making plant are seen in this section.

Marketing

THE ARABS LOOK WEST

The belief grew last week, particularly in American quarters, that no sudden and prolonged upheaval was likely in the Middle East. The eruption in Iraq, painful as it was, proved to be yet another of those political convulsions which accompany the creeping growth of Arab nationalism. It was most unlikely to mean an interruption in the flow of oil to the West.

In time there will doubtless be hard bargaining on the subject of royalties and quotas, for the Arab states will naturally attempt to finance their industrial growth as quickly as possible out of their natural resources. Whatever compromises are struck—and compromises there must be since the Arab countries have the oil and the Western nations the markets for it—the likelihood is that the Arabs will want capital goods in much greater quantities than in the past.

There is little reason to suppose that their aspirations, under Egyptian leadership, will differ greatly from those of India, China, and other underdeveloped countries. Roads, railways, harbours, irrigation schemes, modern buildings and improved housing will be planned and Western help required to realise the plans. With little to develop other than oil and allied minerals, the Arab countries will increasingly turn to manufacturing industries, fed from imported materials, to supply their people's needs. For Britain the opportunities are plentiful and the incentives particularly strong, since British interests account for a very large proportion of total investment in the area. British Petroleum produce 40 per cent of all Iranian oil, nearly 24 per cent of the Iraqi output and half that of Kuwait. The heavy investment this represents should form a sound basis for increased activity of British engineering firms, manufacturers and consultants in Middle East countries. The political risks should not be overrated. For some years at least the main bargaining power lies with the West. Venezuela and the United States can meet any sudden interruption in the flow of Middle East oil by boosting production. Oil strikes everywhere are high and likely to be kept high. The Arab world's future depends largely on the confidence it is able to generate among Western oil companies to ensure an undiminished level of investment.

The eastern area manager of Siemens Edison Swan (Export) Limited, Mr. Peter R. Watson, on his return from a two-month tour of the area summarised very well the market prospects in the Arab world for British engineering products: " the market potential for electrical products is certainly there, and a fair proportion of wealth is allotted to public works and services. The engineers and officials know what they want and competition is keen, but good business is to be had. Technical assistance from this country is always welcomed." Siemens Edison Swan are vigorously attacking the market and have already obtained several large orders, including one of £300,000 for the whole of the cable network of the Amman telephone system. W. H. Dorman and Company Limited have sent out their chief development engineer, Mr. L. Johnson, on an extensive Middle East tour. Other companies are equally active, but there is room for more. The engineering industries as a whole have a magnificent opportunity to get established in markets which, for political reasons, must expand fast, and which, unlike several of the world's main growth areas—South America, India, Africa and China—have all the cash they require to pay for their needs.

Crisis in South Africa

By the end of May the foreign exchange and gold reserves of the Union of South Africa had fallen to their lowest level for nine years. This followed the abandonment during 1957 of credit and import restrictions which has resulted in a favourable balance on the Union's external trading account in 1956. A report entitled " External Trade of the Union of South Africa in 1957," recently published by the Board of Trade, reviews the present situation and the likely impact of current trends in British exports to South Africa. The major changes in 1957, the report states, were the reversal of the right-money policy internally, and the freeing of imports: " liberal credit was made available, by the commercial banks and others, to finance imports and new capital schemes." Imports rose substantially and export revenue was hit by the fall in commodity prices. The South African authorities are now " seriously considering the steps necessary to arrest the decline in the gold and foreign reserves." Once again the Union will have to cut down internal demand, particularly demand for imported goods.

The short-term outlook is not good. Even if the Government do not restore physical restrictions on imports, credit facilities will be sharply curtailed. Already some steps have been taken in this direction and more are expected. Despite this, the Board of Trade consider that " the economy is clearly an expanding one, and the long-term demand for imported goods, and particularly for metal manufactures, vehicles and machinery, will remain an excellent one for suppliers willing and able to meet the particular requirements of the South African economy." It is encouraging that the falling trend over the past few years in the United Kingdom's share of South African imports was arrested in 1957. Competition, particularly from Germany, is increasing, but very good opportunities remain for the engineering firms able to make the necessary effort.

Making Life-Rafts in America

The successes registered from time to time by British companies in the United States suggest that there is scope enough in this vast market for the enterprising. Two British companies, Cory Brothers and Company Limited (a member of the Powell Duffryn Group) and Elliot Equipment Limited, have formed a new American company, Survival Equipment Corporation, with the participation of American interests represented by Estes Industries Inc. of New York, and the C. J. Hendry Company of San Francisco. The new company, controlled jointly by the two British firms, will manufacture at Sausalito, California, marine inflatable life-rafts and other sea rescue aids made in this country by the Elliot company. Aircraft life-rafts and other inflatable equipment will be developed using some of the latest American materials. Other products in popular demand in the United States, such as inflatable canoes and boats, inflatable huts, water tanks and bathing pools, will be made by Survival Equipment.

The key to success in the United States is an adequate distribution and service organisation. Cory Brothers will handle this and make available service depots at suitable locations throughout the United States. This scheme will go far towards providing a world-wide marketing organisation for the Elliot range of products, which was Cory's objective when they became associated with Elliot Equipment.

Hit at Last

The surprising immunity of British exports to the United States recession appeared last week to have ended. In June they totalled £37·4 million, £6½ million less than in May. Despite this fall, exports during the first half of the year were 4 per cent higher than in the first half of 1957—8 per cent more in the case of the United States and almost unchanged in the case of Canada.

The efforts of the Dollar Exports Council have been very satisfactorily rewarded, particularly in the field of private cars and engineering products. The full impact of the recent campaign by Mr. Diefenbaker's Government to increase trade with Britain, on the other hand, has hardly had time to become reflected in trading figures.

Trucks for Brazil

The industrial expansion of Brazil goes on, despite commodity slumps, currency shortages, and other difficulties. The latest mammoth order to be placed—with the aid of a loan from the Export-Import Bank—is for 572 industrial fork-lift trucks. They will be supplied by the Materials Handling Division of the Yale and Towne Manufacturing Company, who claim that is is the largest single export order ever placed for this type of equipment.

The trucks are for use in harbour installations and form a major part of a new materials handling system included in a modernisation programme being carried out in Brazil's 18 leading ports. The two largest, Santos and Rio de Janeiro, will have 132 and 120 trucks, respectively. The whole order is for standard Yale pneumatic-tyred petrol-engined trucks of 4,000 lb capacity, most of them equipped with fluid couplings.

Materials Handling in Scotland

The encouraging response of Scottish industry to the offer of information on materials handling equipment at a local centre in Glasgow by Fisher and Ludlow has led this firm to present a full-scale exhibition of Fisholow materials handling equipment. It will be held from 22 to 26 September in Glasgow. The full range of the company's products will be exhibited and demonstrations held. Among these will be their " Cargon " system, which Fisher and Ludlow claim provides " the quickest turn-round for industrial vehicles." They will also show films illustrating modern methods in materials handling.

Local exhibitions and also mobile exhibitions have gained considerable ground in the past year as an effective means of sales promotion, and will doubtless become even more widely adopted. They certainly present company salesmen with a fine opportunity to display their products and to bring customers and potential customers together. With the latter they have become popular, partly because of the " party " atmosphere which generally prevails, and partly because it is an occasion for meeting local colleagues and competitors. The cost of such exhibitions is high, and it would be interesting to relate this to the value of the exercise in terms of sales—unfortunately very difficult to measure.

Aircraft Exports Records

Aircraft exports have continued to rise. During the first half of this year over £77 million worth of " aviation goods " were sold abroad, 46 per cent more than in the same period last year. The Society of British Aircraft Constructors give details of the composition and destination of these exports in their latest News Letter.

During January to June 1958 the sale of aircraft and parts amounted to £50·2 million, that of aero-engines to £24·2 million, electrical appliances £1·6 million, tyres £272,000 and aeronautical instruments £927,000. India was the leading customer, with £10·9 million, followed by Canada with £9·4 million, and the United States with £4·5 million. Among the industry's larger customers were Western Germany and Iraq. This splendid export achievement, say the SBAC, " forms a fitting prelude " to the Society's forthcoming Flying Display and Exhibition, which is described as the " focal point of the industry's overseas sales drive."

Management

COMPANIES IN THE COMMONWEALTH

With so much talk of the Free Trade Area and Common Market of Western Europe, it would be easy to forget that some notable British engineering firms have established themselves firmly in the Commonwealth. By so doing they are actively helping to create a pattern of working partnerships—among advanced and underdeveloped countries—which will go far to reduce the buffetings of international politics. The United Kingdom has a stake in the Commonwealth and, apart from purely commercial considerations, can contribute to the development of those countries, with the satisfaction of participating in new growths throughout the world. This is the first of a number of articles in which the present position and prospects of British engineering firms in the Commonwealth are examined. The firms chosen are a representative sample and include large groups and small or medium companies.

1—*Hawker Siddeley Group*

The brilliant foresight shown by Sir Roy Dobson when he induced his co-directors of A. V. Roe to invest 2 million dol in Canada after the war has a remarkable similarity to that shown by Lord McGowan when he invested part of the profits earned by Nobel Industries Limited in the first World War in the then comparatively little-known American company General Motors Corporation. The moral—though more commonly stated at the end of the story than the beginning—is that in making a completely new departure in investment one of the most important factors determining success is that it should be in a rapidly expanding economy. By the end of 1957 the Hawker Siddeley holding company, A. V. Roe Canada Limited, had become one of the three biggest businesses in Canada, employing 55,000 through its 44 subsidiaries and, with a turnover of over 400 million dol, accounting for about half the sales of the whole Hawker Siddeley Group. A. V. Roe Canada has certainly come a long way from the day in 1945 when it leased the Victory Aircraft factory at Malton, Ontario, and hired its first 300 employees.

To understand the unpromising circumstances under which Hawker Siddeley first came to Canada it is necessary to examine the state of the Canadian aircraft industry at the end of the war. Whereas at the peak level it was employing 80,000 people in 45 factories, when hostilities ceased 70,000 found themselves out of work and the industry was reduced to 11 plants. In such circumstances, what attracted a British company to stake not only money, but skilled designers and technologists in a seemingly moribund industry?

Probably the major factor was the stimulation by Sir Roy of the gradually strengthening intention of the Canadian Government to make the Dominion as self-sufficient as possible in aircraft. In part this had its origin in the fact that in the early years of the war, Canada found herself largely dependent for fighter aircraft on a strained British industry which could hardly cope with orders from the R.A.F. Another influence was the fact that Canada is dependent on aviation (both air surveys and air transport of freight and personnel) for the development of her mineral resources. Nevertheless, the aircraft division were hard put to it at first to find even sub-contract work. They developed the first jet transport in North America but it never went into production. Gradually, however, orders stimulated by the Korean war began to flow in and the development of the rocket firing CF-100 long-range fighter for the Royal Canadian Air Force was the first major success. In 1946 the company absorbed Turbo Research Limited, a Government-owned company organised in 1943 to develop a jet engine. In 1948 they produced the Chinook, an experimental jet and in 1949 the Orenda, a production model which sold widely. Orenda Engines Limited is now the only organisation in Canada carrying out design, development and manufacture of gas turbine engines. The Orenda " Iroquois " supersonic turbo-jet, which will power the new " Arrow " fighter, is to be built under licence by the Curtiss-Wright Corporation in the United States.

In 1951 Sir Roy Dobson appointed Mr. Crawford Gordon, who had previously worked on defence co-ordination under the Canadian Defence Minister, Mr. C. D. Howe, as president of the company. In 1954 A. V. Roe Canada Limited became a holding company; the aircraft division became Avro Aircraft Limited and the engine division Orenda Engines Limited, already referred to.

The success of the CF-100 long-range fighter has not been confined to Canada. An order was received in June 1957 from the Belgian Government under the mutual aid programme for delivery of CF-100's to the value of 43 million dol. The Orenda engine is being exported by Orenda Engines Limited to Belgium, South Africa, Colombia and West Germany. A spares order worth 8 million dol was received from Germany last year for engines used in F-86 Sabre jets. Interest is also being shown by major American aircraft manufacturers with a view to incorporating Canadian-built engines in American aircraft. Avro Canada have recently completed the construction of a prototype supersonic interceptor which has been claimed to be " half an era ahead of its age." Capable of 1,200 m.p.h. the " Arrow " CF-105 was unveiled in October 1957 and first flew in January of this year. The Canadian Government has spent 200 million dol on its development.

Hawker Siddeley also have a controlling interest through A. V. Roe Canada Limited in the Canadian Car and Foundry Company. The aircraft interests of Cancar involve an important share in the manufacture of the T-34 " Mentor " trainer and the anti-submarine Grumman S2F for the Royal Canadian Navy. Cancar also have exclusive rights to manufacture and sell the " Harvard " trainer and spares throughout the world outside the United States.

Hawker Siddeley are pre-eminent in the Canadian aircraft industry. Their subsidiaries are bigger than their two principal competitors, Canadair (a subsidiary of the General Dynamics Corporation of America) and de Havilland, and Orenda are among the most important aero-engine manufacturers in the world. There are weaknesses, however. Despite the intention of the Government to make Canada self-sufficient in defence aircraft, it is by no means certain, in view of the changing pattern of defence needs, that aircraft will continue to occupy the same position in defence budgets as in the past. If there were to be any sharp reduction in Government orders for aircraft, Hawker Siddeley's Canadian aircraft interests would face difficult times—and in some respects would not be as well placed as their competitors. The interests of Canadair, for example, are well spread in civil as well as military aviation. They make the F-86 Sabre under licence from North American Aviation, the T-33 two-seater trainer under licence from the Lockheed Aircraft Corporation and the two types of military transport, the CP-107 Argus and the CL-44. Design work is at present being done on a new jet trainer, the CL-41. In addition, however, they also made the successful four-engined North Star airliners for Trans-Canada Airways and the Argonaut for BOAC. The CL-44, which is a derivative of the Bristol Britannia, has also been offered for commercial operation and Canadair have rights from Bristol Aircraft Limited for producing and selling it in certain specified areas.

De Havilland are also in some respects more firmly placed for the future than Avro Canada. They make in Canada a wide range of civil and military aircraft including the Beaver and Otter and, under licence, a share in the manufacture of the Grumman CS2F1. They are also, however, working on the production of a new twin-engined STOL* aircraft, the DHC-4-Caribou, which should find a market in the many parts of Canada where it is impossible to land a large aircraft. De Havilland also have a special guided missile section which may make them better placed than Avro to obtain future defence contracts.

On the engine side, Rolls-Royce are now well established in the Canadian market and are expanding their capacity by some 50 per cent. This expansion, which will cost around 1 million dol, has been undertaken principally because of the expanding demand for the Vickers Viscount by airlines in North America and therefore the necessity to carry stocks of spare engines. Sales of the Fairchild F-27 airliner (the Fokker Friendship, made under licence from the Dutch firm), powered by two Rolls-Royce Darts, have been increasing and Grumman Aircraft of New York have announced their intention to power their Gulfstream airliner with two Darts. Rolls-Royce have a particular advantage since the bulk of their Canadian production is used in commercial airliners.

Pratt & Whitney Aircraft are also strong competitors of Hawker Siddeley in Canada. They produce the R1340 Wasp and the 1,525 h.p. 9-cylinder Wright cyclone engines and have just completed a 5 million dol expansion plan.

To provide against the uncertainties in the future of aircraft, however, Hawker Siddeley have adopted in Canada the same policy of diversification which has been a feature of their recent development in the United Kingdom: 70 per cent of their interests are now outside the aircraft industry. Canadian Steel Improvement Limited, for example, which was acquired from the Canadian Government in 1954, had as its original purpose the manufacture of forgings for jet blades. It has since expanded into other fields, including commercial applications calling for precision components in steel, high-duty alloys of aluminium, titanium, etc., and non-ferrous alloys.

Avro Canada's acquisition of Canadian Car and Foundry in 1955 was the first major step towards diversification. Founded in 1905, this company now has four plants and is Canada's largest producer of steel castings. It is also one of the most important manufacturers of motor buses in the Dominion, and makes a wide range of rolling stock and electric trolleybuses. Canada is a growing market for transport equipment of all types and further expansion of Cancar should be assured.

Since its acquisition the steel foundry division

* Short take-off and landing.

Continuing Companies in the Commonwealth

has been split off and a new company, Canadian Steel Foundries (1956) Limited formed. This company, in turn, has joined with English Steel Corporation on a 50/50 basis to start a new company, Canadian Steel Wheel Limited, to make steel wheels hitherto imported from the United Kingdom and the United States. At the time it was acquired Cancar was making a comparatively low net profit on its turnover. Avro have spent considerable sums (believed to be 15 to 20 million dol) on modernisation and expect to get a much higher rate of return in addition to expanding the turnover.

In 1956, Avro Canada widened its base still further by the acquisition of the Dominion Steel and Coal Corporation Limited, of Montreal, together with its 31 subsidiaries. With a payroll of 25,000 and annual sales in excess of 200 million dol, Dosco (whose main operations are at Sydney, Nova Scotia), has been described as the biggest single industrial unit in Canada's four Atlantic provinces. In addition to owning one of North America's largest iron ore properties (Dominion Wabana Ore Limited, St. Johns, Newfoundland) and important coal deposits, Dosco have a fully integrated iron and steel plant which accounts for about 20 per cent of Canada's steelmaking capacity. They also produce a wide variety of fabricated steel structures, railway freight cars, bridges, pylons, naval and commercial ships, mining machinery and a range of light engineering products. Dosco has spent about 100 million dol in modernising its plants over the last ten years and the 76 per cent holding which Avro Canada have acquired makes Hawker Siddeley's Canadian interests one of the largest in the country.

Avro's light engineering interests were also expanded in 1956 with the acquisition of P.S.C. Applied Research Limited, now known as Canadian Applied Research Limited, producing a wide range of electro-mechanical instruments and systems, and Thermo-Couple Limited, manufacturers of domestic and commercial refrigeration equipment.

In April 1957, A. V. Roe Canada Limited, along with associates, purchased 300,000 shares in the Algoma Steel thereby acquiring a large interest. Avro have 150,000 shares, McIntyre Porcupine of Toronto 100,000 shares and Locana Corporation of Montreal 50,000 shares. This represents to some extent a move in the direction of vertical organisation since Cancar, Canadian Steel Improvement, Orenda and Avro Aircraft are all important steel users, but it seems probable that the underlying idea was more one of continued diversification. The shareholders in Locana are Hambros Bank, Harrison and Crosfield and about 40 British investment trusts. Mannesmann, the German tube combine, are building a new 20 million dol seamless tube plant adjacent to Algoma and have a holding of 200,000 shares in the company.

Recently, Avro Canada have announced the extension of their interests into British Columbia, with their acquisition of Vivian Diesels and Munitions Limited, and Vivian Engine Works Limited, formerly part of the Brush Group, and the formation of two new companies: Canadian Car (Pacific) Limited—a subsidiary of Canadian Car Company Limited of Montreal—will operate the two Vivian companies. The other company, Orenda Industrial Limited, a subsidiary of Orenda Engines Limited, will take over and expand the operations of Brush Aboe(Canada) Limited, Brush Group Sales (Western Canada) Limited, and Brush Aboe Inc., New York. Thus Orenda—hitherto engaged solely in the military jet engine field—have now entered the industrial power arena. Initially, Orenda Industrial will be a marketing and servicing organisation for the electrical machinery, diesel engines, turbo chargers and locomotives made by the Brush Group in the United Kingdom—but eventually, when sales warrant, they will undertake manufacture of some products.

Thus, from small beginnings A. V. Roe Canada Limited has emerged in 12 years as probably the biggest British investment in the Dominion since the war. It is known that United Kingdom assets in Canada now amount to some £720 million, of which Hawker Siddeley's interests must contribute something like £120 million—or nearly 17 per cent. They have effectively challenged the Americans on what has hitherto been almost their own ground, and have gained conspicuous success. Their policy of diversification has put them in a favourable position to reap the full benefits from future Canadian expansion.

Recessions will always hit heavy industry from time to time, but broadly, the outlook for the coal, iron ore and steel interests of the group is certainly assured and probably very bright if the past rate of expansion of the United States steel industry is any guide.

It is the aircraft side, which started the group on its Canadian venture, which now poses the main question. The outlook for Orenda Engines seems good so long as they can maintain their lead in design. Orders for the CF-100 aircraft may keep the aircraft company busy until next year. After that much will depend not only on the reception of the Arrow but also on the future for interceptors in general, which is not bright. The closing of the big Hawker plant at Blackpool (formerly employing about 4,000 on the manufacture of Hunters) and concentration of production at Kingston, is a pointer to the trend in the United Kingdom. Hawker Siddeley are established in the missile business in England (for example, with the "Seaslug"): can their associates in Canada follow suit with the benefit of their experience? Finally, Hawker Siddeley—John Brown Nuclear Construction Limited, though not so far advanced in the atomic power field as some of their competitors, are likely to get orders and within, say, the next five or ten years, it would not be surprising to see them established as manufacturers in Canada. Judging from the share options for 321,500 shares at 12½ dol which run until 1966, the Canadian executive directors may be rightly well paid for the remarkable expansion which has been achieved. It may be wondered whether similar enterprise would be more common if remuneration in this way and on this scale were also commoner and more easily effected in the United Kingdom.

Turning to another part of the Commonwealth, Hawker Siddeley have acquired three well-known Australian manufacturing and contracting firms. Thus Hawksley Australia Pty. Limited—hitherto concerned solely with importing aluminium buildings from Great Britain—now becomes a manufacturing group, concerned with making components for the building trade and "packaged" buildings. The firms absorbed are the Bronze Window Frame Company, Melbourne; James S. Samson Pty. Limited, Sydney; and Pacific Electric Company (now Hawksley Pacific Company), Sydney.

Production

HIGH SPEED BEER BOTTLING

The new bottling hall at Benskin's Watford Brewery is equipped to fill 640 beer bottles a minute, and includes a cellar with storage space for 384,000 bottles. Mechanical handling equipment is used to the maximum possible extent.

An area of approximately 13,000 sq. ft is occupied by the plant, which is housed in a building comprising a cellar, ground and first floors. In the cellar there is a filter room with two Filtrox Kieselguhr sheet filters each having a capacity of 40 barrels an hour. There is also a Redox tank installation consisting of eight 50 barrel and six 100 barrel glass-lined Redox tanks. The refrigeration plant for this installation consists of two J. and E. Hall "V-block" compressors, together with evaporators, condensers and ancillary equipment. Ammonia is used as the primary refrigerant and alcohol, instead of brine, as the secondary refrigerant. Compressed air is supplied by oil-free carbon ring compressors. A carbon dioxide recovery plant, a fully automatic water softener, with a capacity of 6,000 gallons per hour, and storage space for approximately 32,000 dozen ½ pint bottles of beer occupy the remainder of the cellar area.

A pallet lift connects the cellar with the ground floor, where there is storage space for a further 48,000 dozen bottles. On the ground floor there are also eight 50 barrel jacketted bright beer tanks for holding filtered beer ready for bottling. These tanks can be coupled to either of the two filters or to the filling machines by means of a stainless steel panel with Avery Hardoll couplings. There is also a complete detergent circulation system for cleaning mains. This consists of two tanks, one containing a hot detergent solution and the other a cold sterile solution. Either or both of these solutions can be circulated. A bulk liquid carbon dioxide tank, of 1½ tons capacity, is situated on the ground floor loading dock.

On the first floor are the two bottling units, which are fed with empty cases by means of conveyors across a bridge from the adjacent old bottling stores. When filled with full bottles the cases travel by conveyor to the ground floor for storage.

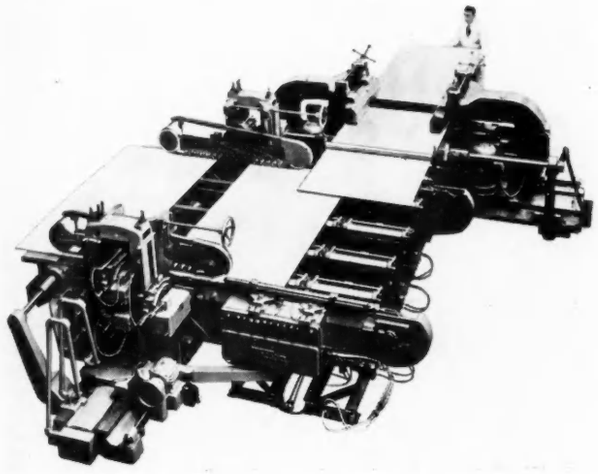
Both bottling units are fully automatic. No. 1 unit has a capacity of 1,200 dozen ½ pint bottles an hour. It consists of a Hopkins unpacker, a Webster bottle washing machine, a Barry Wehmiller double deck pasteuriser, three Comet body and neck labelling machines, and a Lilleshall Webster packer. Cases running alongside the machine are cleaned and turned by a Cookson case turner.

The No. 2 unit can fill 2,000 dozen half-pint bottles every hour. In this line there is a Meyer liquid bottle-washing machine with a four head direct-coupled unpacker. The filler is a 60 head Meyer machine and the pasteuriser is a Barry Wehmiller machine similar to that in No. 1 unit, but larger. There is a three-head labelling machine, a case packer, and a Dawson case washer and turner. Solution for bottle washing is supplied from 14 ton bulk storage tanks on the roof.

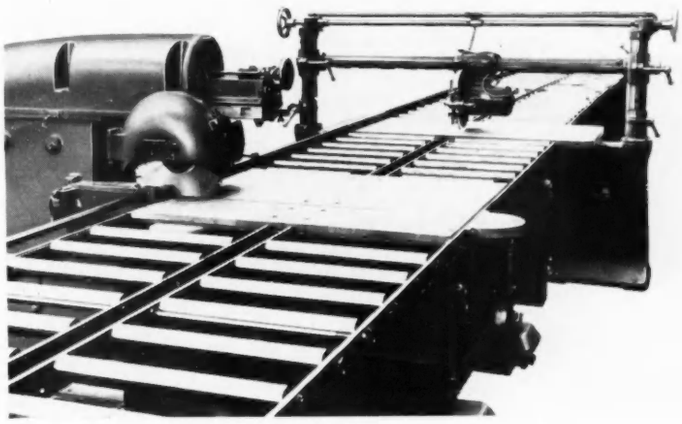
1,000 HOUR LIFE FOR CIVIL AVONS

The Air Registration Board of Great Britain has authorised a life of 1,000 hours between overhauls for the Rolls-Royce Avon RA.29 of 10,500 lb thrust, power unit of the de Havilland Comet 4 and the Sud Aviation Caravelle airliners. Such a high initial overhaul life is unprecedented, and it is expected that further extensions will follow when engines enter regular passenger carrying service shortly.

A target of a 500 hour overhaul life was set when BOAC began an intensive engine-proving exercise in September, 1957. Two Comet 2E aircraft, powered by two RA.29 Avons and two earlier Avons, made daily scheduled flights from London to Beirut and back at an aircraft utilisation of 11 hours per day, accumulating 7,000 hours of flying time on the R.A.29 engines. Only one RA.29 had to be removed prematurely, due to the failure of an ancilliary unit. The engines were stripped and examined by the Board at 250, 500, 750 and 1,000 hour lives.



Automatic trimming of boards or plastics sheets is possible in a range from 18 in to 48 in wide and from 5 ft to 8 ft 6 in long on this Wadkin sawing machine, which embodies fixed and moving headstocks.



For cutting across panels up to 52 in wide, the Wadkin range includes a power-operated machine with manual control. A second saw, as shown in the background, can be fitted for ripping boards into two panels of any required widths.

AUTOMATIC SAWING OF BOARDS AND PLASTICS

Precision trimming of boards or plastics to size can be carried out automatically on a range of machines developed by Wadkin Limited, Green Lane Works, Leicester. One of these machines embodies an infeed double trim saw with dual chain feeding mechanism, which guarantees a very high degree of accuracy, and as feeding dogs are unnecessary it is easy to trim material having irregular edges on all four sides. The machine embodies a fixed and a moving headstock to enable panels between the limits of 18 in and 48 in wide to be handled. Four rates of feed—35, 50, 70 and 100 ft per minute—are provided, and the two 14 in diameter saws, driven by 10 h.p. motors, will cut to a maximum depth of $2\frac{1}{2}$ in. Two additional motorised spindles are available as extra fittings if required, for edge grooving or moulding both sides of the panel.

Feed chains are carried on beams attached to the dual headstock of the second trim unit in the machine. One of the headstocks is movable by hand and power motion along a bed to cater for panels of varying lengths from 5 ft to 8 ft 6 in. Smaller sizes can be handled by removing one or more sections of the roller transfer unit, which is designed for this purpose. The roller transfer unit consists of two fabricated beds carrying four rollers on each bed between the beams of the second machine, and one intermediate roller on each bed between the outfeed of the first machine and the first chain beam of the second machine. These intermediate rollers also have an adjustable top pressure roller to aid in the transfer of the panels. All the rollers are chain driven from the back shaft of the first unit at a slightly increased feed speed. A pneumatically operated rise and fall movement on the transfer rollers between the beams of the second machine allows the panels to be dropped from the track level of the first unit to that of the second unit. The feed arrangement allows each board to ride above and overlap the preceding one during the transfer from the first saw unit to the second; by thus avoiding any pause in feed, maximum rates of production are obtained. Provision is made for squaring the panel accurately between the first and second cuts. The saws on the second unit are 14 in diameter, and can be canted for angular cutting. Additional heads for side grooving and moulding can also be fitted on the second unit if required.

CUTTING TO LENGTH

Another new Wadkin machine is an automatic saw for crosscutting panels up to 52 in wide. This machine has a cutting stroke across the board, operated hydraulically and pedal controlled. Adjustable stops are provided for repetition cutting, and the stroke length can be adjusted to get maximum production on narrower boards. Forward speed is adjustable between 5 and 150 ft per min; return speed is constant at 200 ft per min. The machine has an 18 in diameter saw with a maximum depth of cut of 5 in.

A second saw unit carried on an overhead beam with a rise and fall movement can be fitted to the crosscutting machine, to rip a board into two panels of any required widths. In its simplest form the unit is manually operated, but power movement can be incorporated, together with automatic board feeding.

POWER SCREWDRIVER

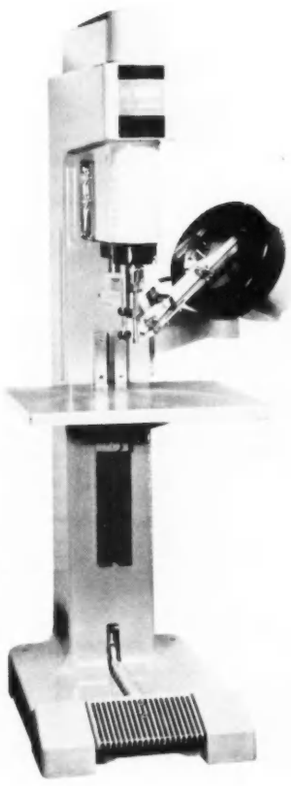
Particularly suitable for incorporation into automatic production lines, but also available for floor or bench mounting, the Model U magazine-fed power screwdriver has been placed on the market by the Detroit Power Screwdriver Company, Detroit, Michigan, U.S.A., a subsidiary of the Link-Belt Company.

The machine has a driving range from No. 6 by $\frac{3}{16}$ in long to $\frac{1}{4}$ in by $1\frac{1}{2}$ in long screws, and has an adjustable clutch giving constant driving torques of from 15 lb-in to 120 lb-in, with a tolerance of $\pm$ 2 lb-in at the lower end of the range and 6 lb-in at the higher end, with any standard screw and under all normal driving conditions.

There are no exposed moving parts. The drive motor and belt, pulleys, upper spindle and clutch assembly are all enclosed in the machine column, easily accessible for servicing purposes. Compressed air actuates the spindle stroke, and there is a pressure regulating valve which permits complete control of the spindle when an operator is required to locate the workpiece visually. The spindle may be stopped at any point in its stroke, and the up and down speeds can be varied as required. A pedal, operating with very light pressure, controls the spindle movements.

In the event of compressed air failure, or in locations where a suitable supply is not available, the spindle can be changed to manual operation by the adjustment of a single screw.

The barrel-type feeder is driven from the main spindle drive motor through a flexible shaft and a gearless mechanism. The latter which requires no lubrication, acts as a safety device in the event of a jam in the hopper. The screw feeder racks are adjustable. The machine is available with or without the pedestal shown in the illustration, or as a completely self-contained driving head for use in automatic transfer lines.



The Detroit magazine-fed power screwdriving machine is available as a floor or bench-mounted model, or as a self-contained head for incorporation in transfer lines.

Research and Development

NON-LINEAR VIBRATIONS IN MECHANICAL SYSTEMS

By F. R. Erskine Crossley, M.A.(CANTAB), D.ENG.

Associate Professor of Mechanical Engineering, Yale University, New Haven, Connecticut, U.S.A.

The study of nonlinear oscillations has received its particular stimulus recently from a desire to explain certain phenomena arising in electric circuits. Nonlinear forms of vibration are more general than linear forms, but as yet mathematicians have not been able to develop a theory from which may be obtained solutions to all the differential equations that arise. The ordinary linear theory of vibrations is applicable, of course, where the motion is small, but it is not adequate. Present practice is therefore to try to develop an approximate theory, which is both reasonably satisfying mathematically and which does interpret the physical experimental results which are being produced. It is probably the ease with which electrical circuits can be built, and the simple way in which readings can be taken from them, that has led to the emphasis upon electrical systems. Mechanical nonlinear systems occur as often, but generally are rather more complex, and tend to suffer from a greater number of parameters, as will be shown: they are also frequently so much more difficult to experiment with, that one of the first considerations is usually whether or not to set up an electrical analogue.

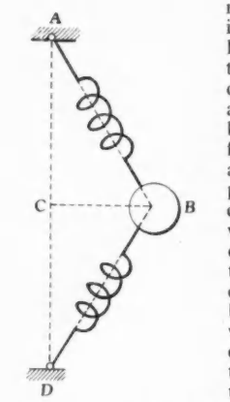


Fig. 1

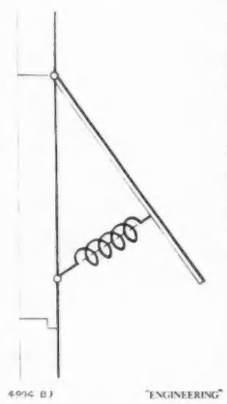


Fig. 2

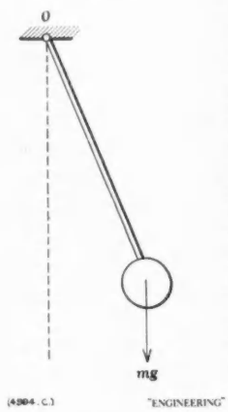


Fig. 3

CLASSIFYING MECHANISMS

It is proposed here that a first step in the solution and understanding of the phenomena which occur in nonlinear mechanical oscillatory systems must be the mental organisation of the geometrical arrangements which exist into classes, with the result that typical equations may be written that govern their motions. From these typical equations it is then possible to extract certain equations representing important basic forms, about which some predictions can be made by comparing them to known electrical forms.

At first it may be well to review some of the current knowledge that distinguishes nonlinear phenomena as observed in experiment. A principal form is represented by Duffing's equation:

$$x'' + c\,x' + \omega^2 x + \beta\,x^3 = \mathrm{F}\cos p\,t \quad (1)$$

which is one of those for which there is no solution. In it, the fourth term with coefficient β is generally, but not necessarily, taken to be small, and as its sign is either positive or negative, so accordingly the system is said to be of hard-spring or soft-spring type. An electrical oscillation governed approximately by this equation may be observed in a simple circuit containing a saturable iron-core inductance together with a condenser and an alternating e.m.f. source. Since the response of a nonlinear system will not be a simple harmonic wave, the equivalent of the usual linear resonance graph will be a plot of the amplitude of the principal harmonic term against the frequency of the forcing function; in the hard-spring case, the sharp rise in this curve that corresponds to resonance appears to lean over forwards, so that larger amplitudes will require higher frequencies to excite them; in the soft-spring case the rise leans backward. A simple pendulum is an example of a mechanical soft-spring system: here the natural frequency is less with larger amplitudes, even becoming zero with amplitude π, because the rate of increase of the restoring force with angle is not constant but diminishes.

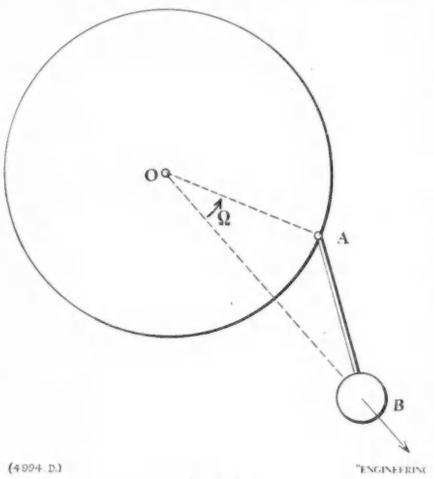
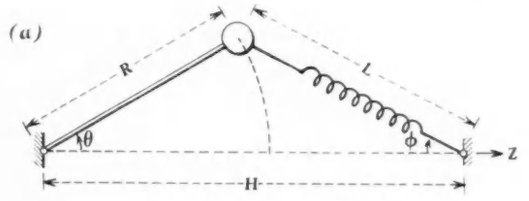


Fig. 4

But if it were merely that from an harmonic excitation an unusual form of response is produced, the subject would not have attracted quite the attention it has; rather it is found that some forms of response can occur in nonlinear systems which are impossible in linear ones. A sub-harmonic response is one such form: this is a forced vibration in which the forcing frequency synchronises usually with the third harmonic term (but it may be with any higher harmonic term) of the response. The basic frequency of the response thus becomes a fractional order of the forcing frequency, the period longer. Sometimes the typical response wave will have a third harmonic component enlarged by resonance, so that it appears to consist largely of about equal amounts of first and third harmonics added together: but under other circumstances the third harmonic may remain quite small in spite of its synchronism with the forcing function, so that the wave appears reasonably near to pure harmonic form with a period that is a multiple of that of the excitation. And it is a further feature of nonlinear systems that these distinctly different responses can occur in the same system when varying initial conditions are imposed, although all other parameters are held invariant.



Figs. 1-5 Triangular arrangement (Class 1) of springs and masses with one degree of freedom and nonlinear relationship of spring restoring force to displacement.

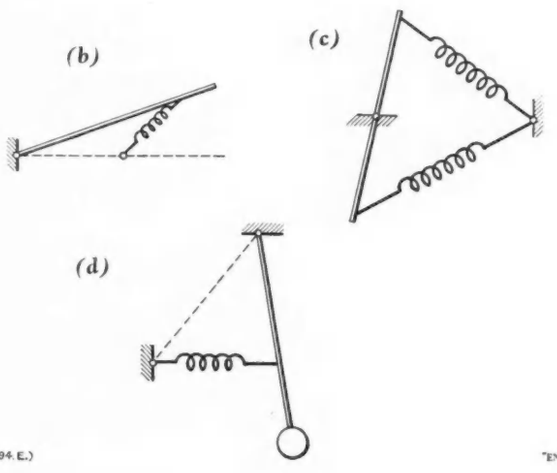


Fig. 5

The several approximate mathematical approaches that are valuable may be found described in available texts (refer to Bibliography items 1-3). In the

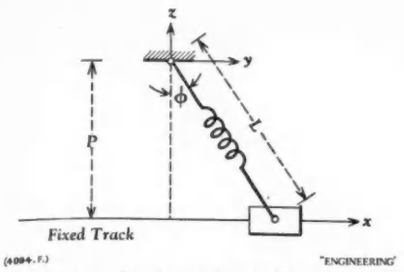


Fig. 6 Ways of applying forced vibrations to the triangular mechanical system.

on a taut string: its underlying triangle is lettered A B C and is right-angled, for in the usual symmetrical case, the triangle A B D may be considered to be folded in half. Fig. 2 shows a door or pivoted lever with a spring to close it. The simple pendulum of Fig. 3 is another elementary nonlinear case: in it the triangle is not so obvious, but the line of action of the gravitational force forms one whose third point has receded to infinity, and then it shows up as merely a special case of the door-closer of Fig. 2. The centrifugal pendulum in Fig. 4 exhibits another triangle.

It is Fig. 2 that provides the clue to a first class among elastic triangles, one that may be distinguished by its one elastic side and one side of constant length fixed in space. Shown again in various forms in Fig. 5, it is plain that there will be three parameters governing its free oscillations: first there is the spring-mass ratio k/m (in which we should expect m to be the equivalent mass at radius R to represent the moment of inertia of the swinging body); secondly the ratio L/R of the movable sides of the triangle, in which L should represent the free length of the spring; and thirdly, there is the very important equilibrium-position parameter expressed by the ratio (R + L)/H. For either of the conditions (R + L) $\leqslant$ H, the system will make symmetrical free oscillations about the central position $\theta = 0$; but should (R + L) $>$ H, there will be two points of stable static equilibrium equally disposed on either side of the centre line, and the centre point will be one of unstable equilibrium. In this case, then, free oscillations are of two distinct types—either symmetrical about the centre $\theta = 0$ (provided the amplitude is large), or about either stable equilibrium point.

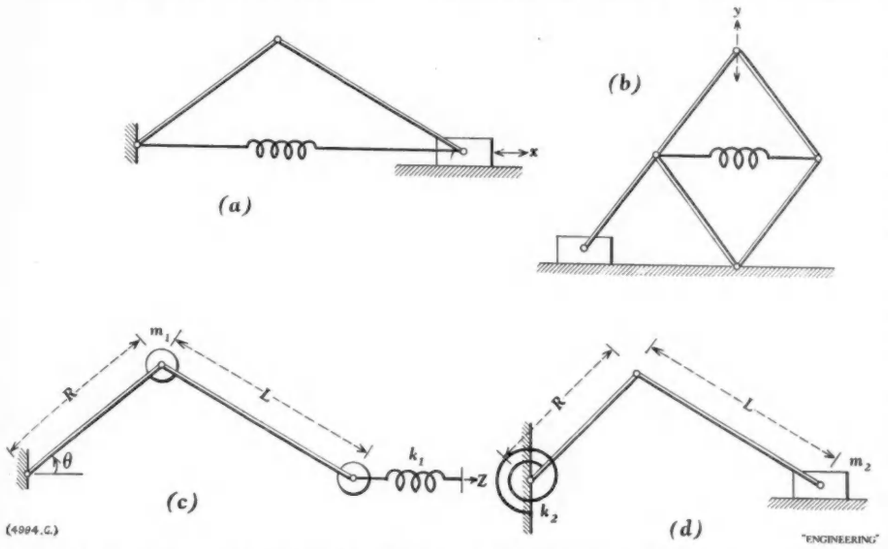


Fig. 7 The second basic class of nonlinear motions is obtained by the kinematic inversion of the triangle—as, for instance, the slider-crank chain.

case of Duffing's equation, as indicated, it is commonly assumed that the coefficient β is small, so that the resultant oscillations can be reckoned to be a variation upon harmonic motion. However, some recent papers have tried to show that even when β increases, the assumption that β is small holds valid as far as experimental results show. Notably Hayashi[4, 5] has considered the equation

$$x'' + c\,x' + x^3 = \mathrm{F}\cos p\,t \quad . \quad (2)$$

and he has produced many experimental results confirming a very boldly approximate mathematical method. Thus, while mathematicians such as Lefschetz and Miss Cartwright[6, 7] attempt to develop the theory on a more satisfactory basis, the engineering approach has been to justify by experiment whatever approximation is most readily obtained, so that it may be possible to describe typical conditions in a typical case. Only then, of course, is it possible to arrive at a general understanding, and thus be able, with assurance, to predict behaviour in new cases. An interesting discussion along this line has been written recently by Clauser.[8]

TRIANGULAR ARRANGEMENTS

Turning now to examine mechanical systems of springs and masses that may be subject to oscillation, let us arbitrarily, but of course necessarily, make a few restrictions. For instance, all sorts of nonlinear characteristics may be designed into a coil spring; we will disregard all these as too ungovernable, and reckon only with springs with linear relationship between force and displacement. Then consider the display of a number of common cases with different geometrical arrangements, that appear as Figs. 1-5. All these are systems restrained to move in a plane, and they have only one degree of freedom. In each arrangement, the existence of a triangle should be noted, and also that the nonlinear relation of spring restoring force to displacement is due to this triangle.

Fig. 1 illustrates the familiar case of a bead

In both these arrangements, combinations of springs complicate the problem, but not greatly. For instance, a linear torsional spring may be attached to the hinge of the " door " in Fig. 5, with the result that the proportion of linear and nonlinear terms in the equation is varied: this proportion means another parameter has been included but the effect is little more than to change somewhat the three parameters mentioned.

Turning now to consider forced vibrations, there are in this class two very different ways to apply the forcing function. On the swinging door we may exert an oscillating torque or angular acceleration in the co-ordinate θ (Fig. 5): and the equivalent in Fig. 6 is a force in direction x or displacement of the anchor pin of the spring in direction y. As opposed to this, the anchor pin may be displaced in the longitudinal direction z. This second method of application directly affects the equilibrium-position parameter (R + L)/H or L/P, and it has often been remarked, since Melde's experiment with a tuning fork, that the principal response to this is the half-order sub-harmonic.

The second basic class of nonlinear motions is obtained by the kinematic inversion of the triangle already considered, so that the elastic side is now laid along the fixed line, with the result that the arrangement appears as in Fig. 7 (*a*). This triangle is recognisable as that of the slider-crank chain or simple engine mechanism. We are content to represent the distributed masses of the two rigid members, crank and connecting-link, by two lumped masses at the pin-joints. And these masses are considered to be controlled by either or both of two linear springs, one acting torsionally on the crank, the other rectilinearly on the slider. Of the combinations of one spring and one mass possible, two create linear systems (that is, k_1 with m_2, the others being absent, and secondly k_2 with m_1) and are thus of no further interest here. The other two pair combinations are nonlinear, as shown in Fig. 7 at (*c*) and (*d*), and are respectively designated arrangements of classes II*a* and II*b*. They might be thought to be different classes, although normally being superimposed in the same system, until it is noted that each is merely an opposite variety of the quadric chain connection (Fig. 8), in which either the one or the other crank is infinitely elongated. We are not anxious to include the quadrilateral in the present discussion, for it occurs much less often.

In practice, both masses m_1 and m_2 occur in the class II motion: thus one more parameter, the ratio of these masses, is introduced. So class II motion has four parameters, where class I has three. But now, with certain special values assigned to the geometrical parameters, special kinematic modifications of the slider-crank chain

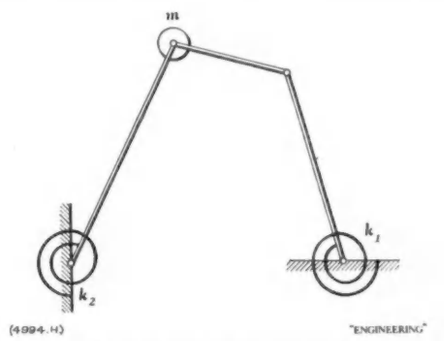


Fig. 8 The quadric chain connection.

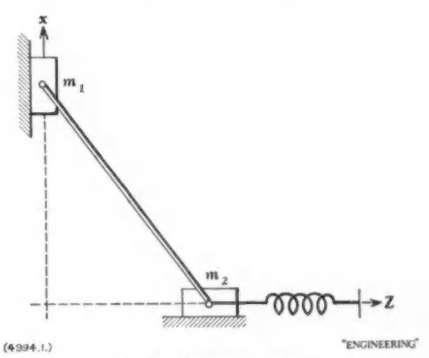


Fig. 9 The trammels.

Continuing Research and Development

are obtained. Thus in one case allow R to become infinitely long, and the mechanism becomes the trammels (Fig. 9); or on the other hand, let L become infinitely long, and the Scotch yoke mechanism (Fig. 10) is obtained.

Forced vibration in this second type of arrangement can again be caused by either of two agencies, comparable in effect to those in the first type. As with Fig. 5 (*a*) so with Fig. 7 (*c*) either a torque may be applied to θ, which is the simpler to study, or a displacement z applied to the spring k_1. The latter form of excitation produces a dominant half-order sub-harmonic.

MATHEMATICAL ANALYSIS

It is possible to start the analysis of class I free and forced motions by writing the general equations with the alternative θ- and z-direction excitations. But the equation is too formidable to be much used. Instead, we examine the types of situation that can occur: it is more profitable to pass from the particular to the general. The varieties of free oscillation possible may be visualised very readily from the potential curves, and from these also the phase-plane diagrams may be constructed, as in Fig. 11. When $(R + L) \leqslant H$, the situation is as given in Fig. 11 (*a*), with a stable equilibirum point at $\theta = 0$ and at every $2n\pi$. There are only two possible free motions—an oscillation about the equilibrium point, or a continuous rotation. Except for variations in the steepness of the sides of the potential curves, and consequent variations in the proportion of harmonics in the wave-form, the situation both as regards free and forced motion corresponds in every way to that of the simple pendulum.

When $(R + L) > H$, the potential and phase-plane curves appear in general like those in Fig. 11 (*b*). Here there are three distinct forms of free motion, depending on the energy level. With variations in the parameters L/R and (R + L)/H, the relative heights of the two humps in the potential curve will vary. The two interesting special cases are (i) when R becomes infinite, giving the " taut string " form, with the result that the angle θ cannot exceed $\pi/2$, the higher potential summit is then infinitely high, and the number of possible free motions is therefore reduced to two; and (ii) when L becomes infinite, in which case the stable equilibrium values of θ reach a right angle, and strangely we get back to the simple pendulum case again. For note the line of the spring is then always effectively parallel to the centre line, so that the equation of free motion is

$$I\psi'' + k R^2 \sin\psi \cos\psi = 0 \quad . \quad (3)$$

where ψ is the angle measured from the equilibrium point, that is $\psi = \theta - \pi/2$; and then put 2ψ equal to χ, and obtain instead:

$$I\chi'' + k R^2 \sin\chi = 0,$$

which is the pendulum equation. This case is shown by potential and phase-plane curves in Fig. 11 (*c*).

A considerable amount of study has already been concentrated on the motions possible in such a typical soft-spring system as the pendulum. Its resonance curve will exhibit the usual form leaning backward and sub-harmonic resonances are to be expected, and have been produced, for the orders one-third and one-fifth. Higher odd-number sub-harmonics may occur rarely; even-number sub-harmonics are unlikely.

The " taut string " type for the case with the unstable central equilibrium point is a definite new type, that is rather easier to take next than the general class I with $(R + L) > H$, and the results are likely to be very similar. Considerable work has recently been done on this, and whereas the quantitative results are soon to appear in another paper by the author, some general observations are as follows.

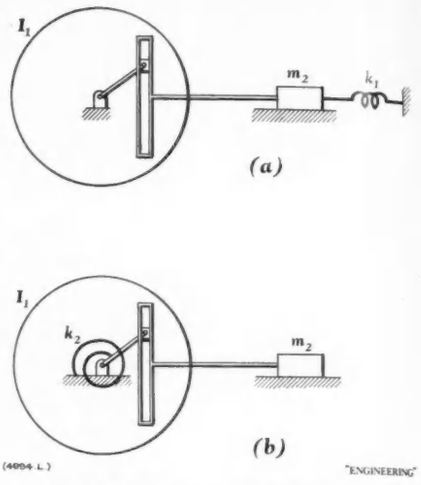


Fig. 10 The Scotch yoke mechanism.

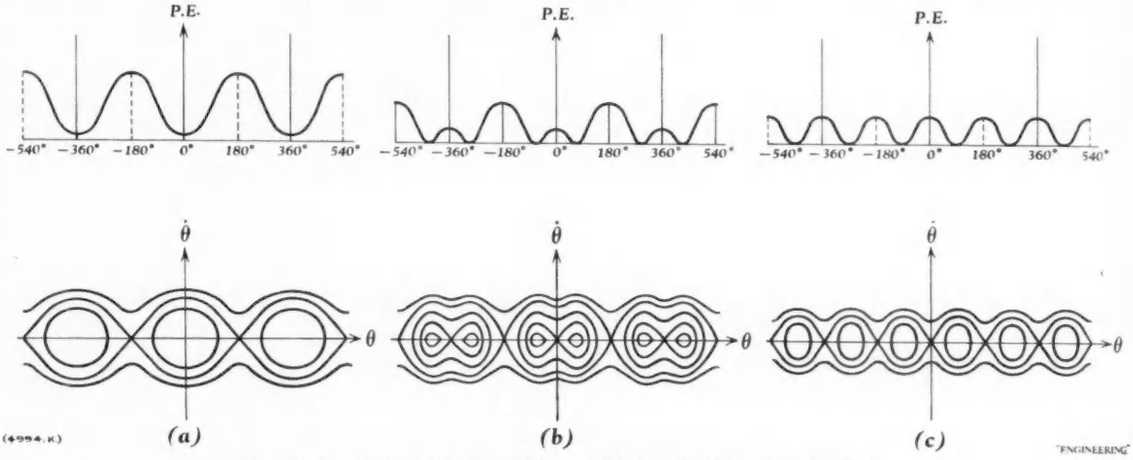


Fig. 11 Phase-plane diagrams of free oscillations for Class 1 mechanisms.

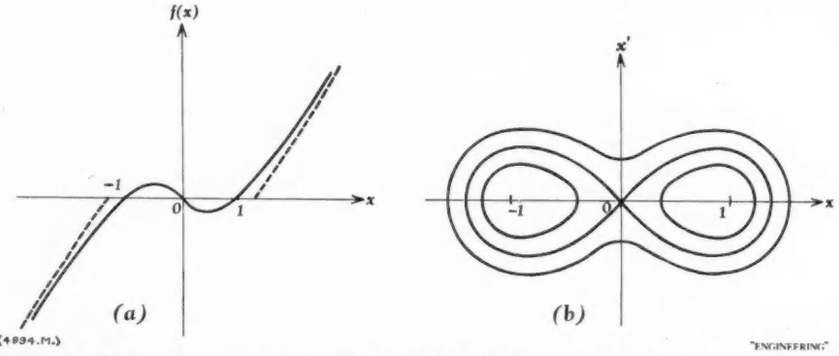


Fig. 12 Oscillations about a central saddle point for the body represented in Fig. 6 (a) spring force component as function of displacement; (b) phase-plane diagram.

OSCILLATIONS ABOUT A CENTRAL SADDLE-POINT

For the body in Fig. 6, having mass m, and restrained by the spring of stiffness k, of free length L and with its anchored end displaced from the line of oscillation a perpendicular distance P, the equation of motion is

$$m x'' + c x' + \frac{k x}{\sqrt{x^2 + P^2}}(\sqrt{x^2 + P^2} - L) = 0 \quad . \quad . \quad . \quad (4)$$

where c is a damping coefficient.

If immediately we introduce the parameters, and change to the non-dimensional variables, defined by

$$\xi = \frac{x}{P}, e = \frac{L}{P}, \omega^2 = \frac{k}{m}, \omega t = \tau, \gamma = \frac{c}{m\omega}$$

then with respect to the variable τ, equation (4) becomes

$$\xi'' + \gamma\xi' + \xi - e\frac{\xi}{\sqrt{1 + \xi^2}} = 0; \ (e > 0) \quad (5)$$

The last term incidentally is the trigonometric function $\sin(\tan^{-1}\xi)$; it has a unit slope at the origin. Now the case that is of particular interest here occurs when $L > P$; that is, when $e > 1$. The graph of Fig. 12 (*a*) shows the spring force component as a function of the displacement: the three equilibrium points occur where

Restoring force =

$$f(\xi) = \xi - e\frac{\xi}{\sqrt{1 + \xi^2}} = 0 \quad . \quad (6)$$

i.e.,

$$\text{at } \xi = 0 \text{ and at } \xi = \pm\sqrt{e^2 - 1} \quad (7)$$

Thus, for instance, where $e = \sqrt{2}$ the two static equilibrium points occur where $x = P$ (Fig. 6) and the angle $\phi = 45$ deg. This is the particular case for which Fig. 12 (*a*) was drawn. The phase-plane diagram of possible free oscillations is shown in Fig. 12 (*b*).

Forced vibration can be excited in the simple manner by a harmonic force in direction x. In this case the equation is

$$\xi'' + \gamma\xi' + \xi - e\frac{\xi}{\sqrt{1 + \xi^2}} = \zeta\cos\nu\tau \quad (8)$$

where F cos Ωt is the actual force applied, $\zeta = F/kP$ and $\nu = \Omega/\omega$.

Now it is interesting to expand the radical in this equation and obtain the form

$$\xi'' + \gamma\xi' + (1-e)\xi + \tfrac{1}{2}e\xi^3 - \ldots = \zeta\cos\nu\tau \quad (9)$$

From this it is plain that for the simpler case with the one stable equilibrium point in the centre, that is, when $1 > e > 0$, the natural frequency for small oscillations is $\sqrt{1-e}$, or the line $\zeta = 0$ in the resonance diagram (Fig. 13) must rise from the point $\nu^2 = 1 - e$. It is also apparent from the geometry that, for very large amplitudes, the natural frequency will be almost independent of the value of P (or e), approaching the value $\sqrt{k/m}$, which means that the median line $\zeta = 0$ on this same response curve will become asymptotic to the ordinate $\nu^2 = 1$. From this argument, for the more interesting case $e > 1$, it follows that the median line $\zeta = 0$ in the response curve (Fig. 13 (*b*)) should rise from the imaginary point $\nu^2 = 1 - e$. This ties in very well with the other obvious fact that free oscillations about the centre have a minimum amplitude represented by point B that (from the separatrix of the phase-plane or from the potential energy curve) is found to be $2\sqrt{e^2 - e}$; this is borne out in experiment. In the case of forced vibrations, however, the lower branch of the response curve (between J and K on Fig. 13 (*b*)) is also a stable condition; responses of this type, with very small amplitudes about the centre, antiphase to the excitation, have also been observed.

For the usual hard-spring case, the resonance line for the third order sub-harmonic is to be expected at nearly three times the frequency of the ordinary resonance. So in Fig. 13 (*a*), for instance, it will appear as the line C D, rising from a point near $\nu^2 = 9\ (1 - e)$. In the second case, though, $(1 - e)$ is negative, so that this line must cross the ν^2-axis to the left of the ordinary resonance line, as the line E F.

But then there is also the other mode of motion, not about the centre, but about either point of stable equilibrium. For this it is better to convert the equation by the substitution $y = x - \sqrt{e^2 - 1}$; this transfers the origin to one of the centres of stable equilibrium. The equation corresponding to equation (9) then acquires terms of even powers as well as the odd powers:

$$y'' + \gamma y' + \alpha y + \beta y^2 + \epsilon y^3 + \ldots = \zeta\cos\nu\tau \quad (10)$$

with

$\alpha = h^2/e^2$, for $h = \sqrt{e^2 - 1}$; $\beta = h(4e^2 - 1)/2e^4$; etc. And thus it is possible to draw a supplementary response diagram of the soft-spring type, with the free ($\zeta = 0$) line rising from the point $\nu = h/e$ for small oscillations about $x = h$, that will be superimposed on the lower part of Fig. 13 (*b*). And there must also be further oscillations in this mode from the one-half order and one-third order sub-harmonic excitations, the former plainly due to the asymmetry of the spring force curve about $x = \pm h$.

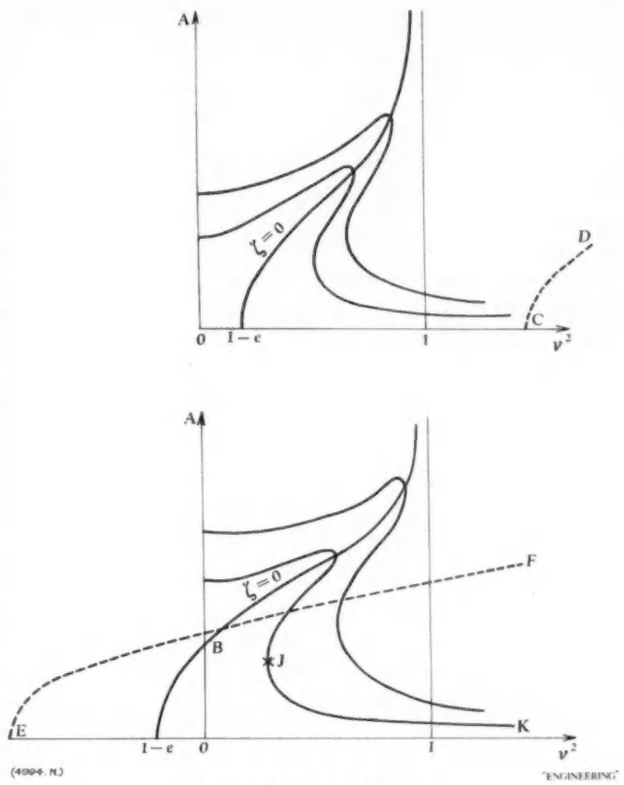


Fig. 13 Resonance diagram.

All these have been observed.

Concerning the further modes of motion that are possible in the general (swinging door) class I arrangement, no further work has yet been done, nor has any work been done on the class II form. Speculation is a field on which anyone may wander capriciously; but the outline above demonstrates the rapid progress that can be made once the geometrical forms are classified.

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SENSE OF DIRECTION

There has been a good deal of discussion about the future prospects of the British Internal Combustion Engine Research Association, Slough, Bucks. This has occurred both inside and outside the Association, and is commented on in its June *Bulletin*. The re-assessment of the association's premises for rates and the expiry of the original lease—to mention only two items—have caused an increase of well over £5,000 in the cost of running BICERA in the last financial year, compared with two years ago. However, an inquiry among members showed that many were willing to pay increased contributions, although this would be regarded as a last resort.

The possibility of some form of merger with the Motor Industry Research Association was examined, but it became clear that this was not feasible. A third possibility that has been examined is the extension of research and development of some of BICERA'S devices. This proposal was received favourably and it is hoped that the resulting additional income will be sufficient to avoid an increase in the general contribution rate.

This year, the Research Committee reviewed not only the items in the research programme but also the general structure of the programme, the balance between fundamental and applied research, and methods of approach—to ensure that the best use was made of available knowledge and resources. Three representatives of the committee also spent a day at the laboratory examining the allocation of staff among the various research activities; as a result they were able to report on the needs of the laboratory.

Within the laboratory, too, the method of presenting the results of research is being examined with the object of making them more directly applicable to the needs of the individual member. For this task, comments of member companies during the Director's recent series of visits have provided useful pointers.

How much direction should be given to basic research, and the correlation of it with applied research within any given institution, are recurrent topics of discussion. The Director of the Department of Terrestrial Magnetism, Carnegie Institution, Washington, comments in his *Report* for 1956-57 that basic research "is usually described as simply the active expression of a curious or inquiring mind, whereas applied research is goal-directed and motivated by the hope of useful (and profitable) application." But he points out that there is a considerable area of overlap, as much of the activity of an investigator in "pure science" is goal-directed and practical to a high degree. This is because his deep interest in certain problems drives the investigator to find usable solutions to difficulties which he discovers must be overcome before he can examine or understand certain processes or conditions encountered in his studies.

The description of all research workers as "goal-directed" emphasises the value of BICERA'S review of their research programme. Just as a homing missile will reach its target quicker if it is pointed in the right direction to start with, so will a research worker attain his goal faster if he starts out on the right track. Every goal-seeking mechanism has a time limit.

THERMISTORED CRYSTAL OSCILLATOR

A new type of thermally-compensated crystal oscillator has recently been patented by Automatic Telephone and Electric Company Limited, Strowger House, 8 Arundel Street, London, W.C.2. The oscillator, which is essentially of a conventional type such as the Pierce, has a temperature-compensating network controlled by a thermistor mounted inside the crystal envelope. A complete unit is available as a small sub-assembly that can be incorporated in a wide variety of equipment. At present, operation on any spot frequency between 4 and 16 Mc/s is possible, and a stability of ± 5 parts per million over a temperature range of -20 to $+70°$ C can be expected. The current consumption is 8 mA at 230 V and 0·3 A at 6·3 V. Units are ready for operation within a minute or two of switching on.

Research and Development

STRENGTHENING THE LINKS OF RADIO

Radio Research Station Advised to Increase Work on Terminal Equipment

In *Radio Research* 1957, the Radio Research Board recommend that a broader programme of research should be followed by the Radio Research Organisation of the Department of Scientific and Industrial Research. The greater part of the organisation's work is carried out at the Radio Research Station, Slough, and is at present mainly devoted to various aspects of wave propagation in relation to the wide variety of applications of radio. This work is important, say the board, and should continue, taking advantage of the prospects offered by new tools, such as artificial satellites and rockets. But the research programme should be broadened in scope to take account of present and future demands.

The research work of the station provides basic information for the radio and electronics industry, the Armed Forces, government departments, broadcasting, and other " user " authorities. The Board envisage developments that will form a corollary to the work on wave propagation and ensure that the station keeps in step with other important topics, making its own contribution to their advance. The current work there on special radio materials and devices is proving valuable, and, in the opinion of the Board, should be extended to cover other aspects, such as the properties and applications of molecular amplifiers and oscillators. They also believe that basic research should be initiated in such fields as the design and properties of microwave aerials, and ways of transmitting information that achieve economy in the use of the radio frequency spectrum. In general, any subjects chosen for study in the future should conform to the pattern that past experience has shown to be the most useful, namely, they should be generic rather than unduly specific but should be stimulated by, and be as relevant as possible to, practical applications. The development of secondary-standard measuring techniques for the highest radio frequencies is also advised. The Board recognise that considerable expansion in staff will be necessary to meet the requirements.

In fact, existing numbers are insufficient to cope adequately with present needs. Indeed, although some increase has occurred in the staff of the experimental officer and assistant (scientific) class, no additional scientific officers have been recruited in 1957. In the Board's opinion, a steady inflow of scientific officers of high calibre is essential to the future wellbeing of the establishment.

During the year, two subjects on which active research is not being carried out by the Radio Research Organisation received attention after the Organisation's advice was requested. The first arose from the trend towards the use of higher powers at centimetre and decimetre wavelengths: it is possible that the energy flux in the immediate neighbourhood of the aerial may be sufficiently intense, in special circumstances, to produce heating effects harmful to the human body.

There have been many reports on this subject and the advice of the Medical Research Council is being sought in their assessment. The second subject concerned the part played by noise of an extra-terrestrial origin in limiting the useful sensitivity of receiving equipment at frequencies above 100 Mc/s. In the higher part of the frequency band considered, noise originating in the receiver is at present more troublesome than extra-terrestrial noise. But future developments in low-noise amplifiers—molecular devices, for example—may change this situation. The Radio Research Board have therefore recommended the publication of a paper, prepared by a member of the Organisation, to consolidate the information available on extra-terrestrial noise into a form suitable for use by communications engineers.

An account of the work of the Organisation during 1957 is given in the report of the Director of Radio Research. Two aspects are summarised below.

IGY WORLD DATA CENTRE

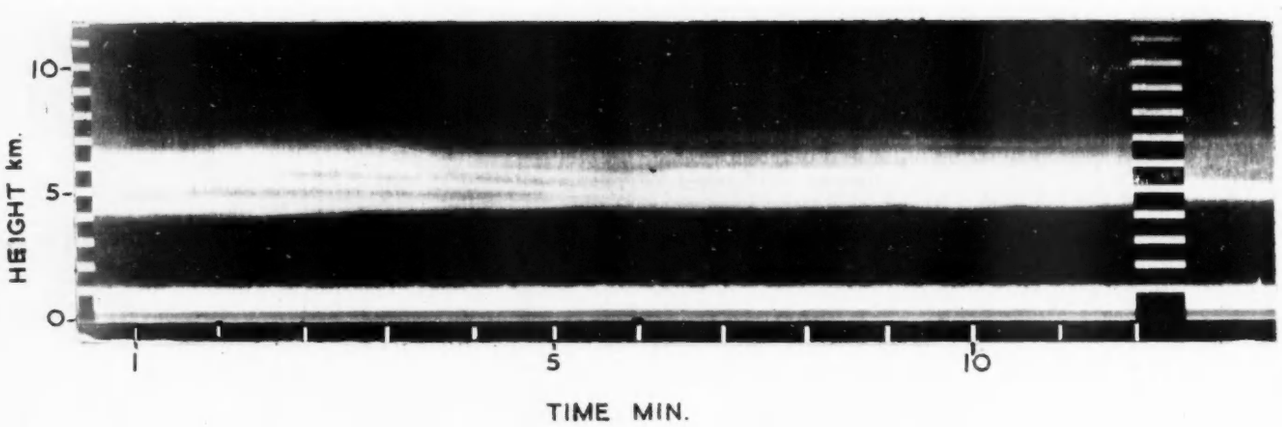
During the International Geophysical Year, the normal programmes of observation of the characteristics of the ionosphere and of atmospheric noise, which have been in operation for many years at the Radio Research Station and its associated substations, are being extended in accordance with the recommendations of the International Special Committee for the IGY. This implies not only more frequent observations on the prearranged Regular World Days and during Special World Intervals (arranged at short notice to coincide with unusual solar activity), but also the commencement of new types of observation at several stations.

The great amount of data which is accumulating throughout the world during the IGY must be made reasonably accessible to individuals and organisations in all countries. To achieve this result, arrangements have been made for each observing station to send its data to a specified World Data Centre. For ionospheric and certain allied research programmes, four such centres have been established: at Boulder (Colorado), Moscow, Tokyo and the Radio Research Station, Slough. Each centre will send copies of the data received by it to the other three; the exchange taking place as far as possible in the form of 35 mm film.

It is expected that about 2 million tables of data or photographic records will eventually be collected. A card-index system has been designed that will simplify the problems involved in controlling the flow of data during the IGY; it will also provide a quick, permanent means of tracing any required information. The whole of the information collected at a World Data Centre will be available for consultation by arrangement, and, later, it will be possible to purchase copies of specified data.

In addition to the four ionospheric observatories manned by staff of the Radio Research Organisation, at Inverness, Port Stanley, Singapore, and Slough, other observatories sponsored by the United Kingdom are in operation at Halley Bay (Antarctica), Ibadan (Nigeria), and Port Lockroy (Grahamland). The equipment for the last-mentioned stations has been designed or built at the Radio Research Station and staff have been trained there. Data from all seven of the observatories are sent monthly to Slough.

Observations were made at Slough on the U.S.S.R. artificial earth satellites. These gave transmissions on about 20 and 40 Mc/s, and the orbiting height was such that the satellites were sometimes within, and sometimes above, the main regions of the ionosphere. On 20 Mc/s, the bulk of the observations were of a directional character; a few measurements of the angle of elevation were made but most work was done using a conventional cathode-ray direction-finder for azimuth determination. On 40 Mc/s, frequency measurements were made showing the Doppler shift due to the motion of the source, and the bearing and elevation angle of the received radiations were also determined. The Doppler data have so far received preliminary study, taking into account the knowledge of ionospheric structure obtained from routine ionospheric



Radar reflections from an elevated tropospheric layer. The equipment operates on a wavelength of 10 cm and is directed vertically upwards. Obtained during anti-cyclonic conditions, the intensity modulated display indicates a thick reflecting layer between the heights of 4 and 7 km, with a fine structure discernible. The only cloud visible overhead was of the cirrus type, filling about one-quarter of the sky. (*Crown Copyright*)

soundings, and also orbital information at present available. Fuller examination of the directional data in relation to the deviations introduced by the ionosphere will be undertaken when the position of the satellites as a function of time is known more accurately.

TROPOSPHERIC SCATTER

Although it is known that tropospheric scatter propagation arises from the presence of irregular variations of the refractive index, or its gradient, in the lower atmosphere, the exact nature of the propagation mechanism is not understood. One explanation is that as a result of random fluctuations of refractive index caused by turbulent motion in the troposphere, virtually the whole of the troposphere may contribute to the signal which is received, although fluctuations in the region in which the beams of the highly directive aerials, used in this type of transmission, overlap are predominantly responsible for the signal.

An alternative explanation is that the long-distance propagation is due to refractive index variations in relatively restricted layers of the troposphere, where the variations may frequently be of a less random nature than is assumed in the other theory. It is possible that neither of the theories is, by itself, capable of affording an explanation of all the observed phenomena: a combination of the two may be required. But, at present, the relative contribution of the two mechanisms to scatter signals in general is not known.

Investigations are in progress at the Radio Research Station to discover the solution of this problem, because the use to which communication links using tropospheric scatter propagation can be put depends on the nature of the propagation mechanism: for example, the bandwidth of the signals which can be transmitted without distortion will almost certainly be different for different mechanisms. Experiments are currently being carried out at 53, 1,370 and 3,500 Mc/s.

The investigation at the highest frequency is being carried out in collaboration with the Ministry of Supply, the Admiralty, and the General Electric Company Limited. Equipment has been assembled for receiving continuous wave transmissions over a 260 km path, with the object of measuring the angular distribution of the incident energy. This knowledge is of fundamental importance in understanding the mechanism of tropospheric scatter and for designing aerials for practical communications systems.

Twin receivers, using a common local oscillator have been installed. These enable the rapidly-fading transmissions to be received from two aerials simultaneously and recorded side by side on a strip of film; the correlation between the recorded amplitudes can be calculated over any desired period of time. When the two aerials are small and close together, they are sampling the incident field at substantially the same point in space and the fading of the outputs from them will tend to be in synchronism, giving a value of unity for the correlation coefficient. As the spacing between the aerials is increased, the correlation coefficient falls, and the manner in which it falls can be used to estimate the angular distribution of the incident energy in the plane containing the direction the aerials have been spaced in.

In order to obtain the vertical and horizontal spacing required, a transportable T-shaped structure has been constructed at the Radio Research Station. It consists of a 20 metre vertical member and an 8 metre horizontal member; carriages supporting aerials are arranged to run along both members. Also, as the evaluation of the correlation coefficient by scaling amplitudes from film is a lengthy process, an analogue computer has been constructed to perform this operation.

Preliminary tests were made with two vertically-spaced paraboloids, 1·2 m (13 wavelengths) in diameter, used as receiving aerials. A correlation coefficient of unity could not be achieved, even with the aerials adjacent. Consequently, the paraboloids were replaced by small sectoral horns, each being two wavelengths square in aperture. It was then found that with the correlation coefficients evaluated over periods of a minute or so, the rectified outputs from the two receivers were substantially uncorrelated in amplitude at vertical spacings varying from about 1 to 2 m (10·5 to 21 wavelengths); this corresponds to energy arriving over an angle of roughly 2° in the vertical plane. Over much longer periods of time, slow variations in amplitude were evident when the rapid fluctuations were smoothed out, and these were usually correlated even at the largest vertical spacings possible with the system (about 17 m), but were not always so. Similar work with horizontal spacings between the aerials has recently commenced.

At 53 Mc/s, highly directive aerials have not been used. The source of the transmissions was the sound channel of the BBC television station at Kirk o'Shotts, Scotland. In spite of the length of the transmission path (530 km), the received signal could be observed above the noise level of the receiver for practically the whole time by using an effective bandwidth of a little less than 100 c/s. It has been found that signals over this path were only seldom those usually associated with a random scattering process. During intense anti-cyclonic conditions, it appeared that only one or two transmission paths were concerned, but much of the time the received signal showed characteristics suggesting a combination of the two extreme mechanisms, with the "scatter" component playing a relatively minor part.

The experiments at 1,370 Mc/s are being carried out in collaboration with the General Post Office. Paraboloidal reflector aerials are being used for both transmission and reception, and the path length is 150 km. Thus the conditions are similar to those encountered in practical scatter links. There are many points of similarity between the field-strength recordings obtained at 53 and 1,370 Mc/s, the main difference lying in the relative fractions of the time for which each type of recording is observed in the two instances. It is thus considered that the results obtained in these investigations so far indicate the important contribution to the received signals due to the refractive index fluctuations confined to relatively restricted layers in the troposphere. Besides the work described, information is also being acquired on fading rates and signal-to-noise ratios.

Investigations in the diurnal and seasonal variations of the monthly mean values of the refractive index of the atmosphere at ground level, and also the variations of the average gradient of the refractive index over the first 1,000 m of the atmosphere above ground level, are also being carried out. In addition, a radar technique is being used to study the structure of the troposphere at vertical incidence. The sensitivity of the system is such that an echo can be obtained at a range of 1 km provided the effective scattering cross-section of the tropospheric irregularity concerned is at least 10^{-8} sq. m. Although echoes have been recorded in all kinds of weather, it appears that there is a greater probability of the occurrence of echoes during anti-cyclonic conditions.

The equipment operates at a wavelength of 10 cm. The transmitter has a peak power of 450 kW, a pulse length of 0·5 microsec, and a repetition frequency of 500 pulses per second; it is thus possible to obtain a range discrimination of 75 metres. A paraboloidal aerial with 3 metres aperture diameter, set with the plane of the aperture horizontal, is used for transmission and reception. Scattered or reflected energy has been recorded from heights up to 5 or 6 km.

The results of this investigation have been encouraging, and it is hoped that with developments of the technique—including the use of shorter pulses and aerials with greater gain, and also with the use of other frequencies—much valuable information concerning the refractive index structure of the troposphere will be gained.

TESTING HELICOPTER ROTORS

A new rotor blade test tower has been designed and built by Bristol Aircraft Limited to test production rotor blades for helicopters. The tower—an octagonal steel and concrete truncated cone, 18 ft high and 20 ft across the base—is built solely for production testing.

The tower represents the hovering condition, but, as the control systems of individual aircraft vary within small limits, the final adjustments can only be made after flight testing. Nevertheless, the pre-flight testing of the aerodynamic profile, lift, out-of-balance, and tracking characteristics enables a stock of fully tested blades and hubs to be maintained for spares, and speeds the clearance of damaged blades returned for overhaul and repair.

The drive to the rotor is from a 400 b.h.p. main motor, by way of a gearbox and vertical drive shaft fitted with a standard rotor hub. A mixed Ward-Leonard and shunt control system is used to adjust the speed of the motor over a range of 80 to 1,264 r.p.m. The motor was supplied by Crompton Parkinson Limited, Aldwych, London, W.C.2.

A constant speed motor generator set, comprising an auto-synchronous motor with an exciter and a generator with its exciter, runs at 1,000 r.p.m. The set and its control gear are housed in a sub-station adjacent to the tower. To facilitate the changing of blades, a working platform which may be raised or lowered electrically is powered from a point external to the tower. The platform is shown in the accompanying illustration. Safety devices are incorporated in the driving motor circuits to ensure that the rotor blades cannot be set in motion when work is in progress on the blades.

Helicopter rotors are tested under hovering conditions in this tower, the main drive being from a 400 h.p. direct-current motor.

NEW BOOKS

The British Shipbuilding Compendium 1958. Eighth Edition. *The Shipping World Limited, Effingham House, Arundel Street, Strand, London, W.C.2.* (20*s.*)

The firms engaged in building and repairing ships in Great Britain and also the principal sub-contracting firms supplying materials and equipment are listed in this handbook. There is also a section dealing with shipyard equipment.

Newnes Engineer's Pocket Book. By F. J. CAMM. *George Newnes Limited, Tower House, Southampton Street, Strand, London, W.C.2.* (10*s.* 6*d.*)

The fourth edition of this compact handbook of engineering tables and formulae for mechanical engineers has been fully revised, and among the many new tables added are two for unified screw threads, coarse and fine.

The Electrical Engineer's Reference Book. Edited by E. MOLLOY and M. G. SAY. *George Newnes Limited, Tower House, Southampton Street, Strand, London, W.C.2.* (80*s.*)

An important addition to the ninth edition of this work of reference is a new section on analogue and digital computers. The first section of the book on theory and calculations has been revised and includes new sub-sections on nuclear physics, electromagnetic machines, and transmission theory. The section on power-station practice has been completely re-cast to take account of the rapid development of nuclear power and hydro-electric schemes, and the increasing interest in the possibilities of wind, tidal and solar power. The materials section now includes data on silicone insulating materials, and information on materials for nuclear reactors, and ferro-electric materials. There are additional data on aluminium detectors, sheathing and submarine power cable installations.

Surface Energy of Solids. By V. D. KUZNETSOV. A translation from the Russian by the Department of Scientific and Industrial Research. *H.M. Stationery Office, York House, Kingsway, London, W.C.2.* (8*s.* 6*d.*)

The important part played, in the science of solids, by the surface is discussed by the author in all its aspects, including the growth of crystals from solutions or melts and deformation questions. The concept of the surface energy of a solid and its relation to the hardness and other properties of the solid are set out from the physical and mathematical points of view.

The Strength Properties of Plywood. Part 4: Working Stresses. Forest Products Research Bulletin No. 42. *Her Majesty's Stationery Office, York House, Kingsway, London, W.C.2.* (2*s.*)

An analysis of the test data accumulated in investigations on plywood is set out in this *Bulletin*. The stress values, suitable for use in design calculations, are suggested for a number of wood species when used in plywood.

Iron and Steel Making in Poland. A Report to The British Iron and Steel Federation by a British Delegation, 1957. *The British Iron and Steel Federation, Steel House, Tothill Street, London, S.W.1.*

The tour of the British delegation to the principal iron and steel making plants in Poland was made in October, 1957. Their report begins with a general review of the Polish iron and steel industry and its organisation; it then goes on to consider the raw materials employed and their sources and preparation. Further chapters and sections deal with iron and steel making plants, rolling mills, tube-making plants and other subjects.

Lloyd's Register of Shipping Register Book 1958-59. Vol. I: Register of Ships. *Lloyd's Register of Shipping, 71 Fenchurch Street, London, E.C.3.* (360*s.*)

Lloyd's Register of Shipping Register Book 1958-59. Vol. II: Appendix. *Lloyd's Register of Shipping, 71 Fenchurch Street, London, E.C.3.* (80*s.*)

Lloyd's Register of Shipping Register Book 1958-59. Vol. III: Shipowners. *Lloyd's Register of Shipping, 71 Fenchurch Street, London, E.C.3.* (40*s.*)

Proceedings of the International Conference on Fatigue of Metals. *Institution of Mechanical Engineers, 1 Birdcage Walk, Westminster, London, S.W.1.* (90*s.*)

The 80-odd papers submitted for the International Conference on the Fatigue of Metals, held in London from 10 to 14 September and in New York from 28 to 30 November, 1956, have now been published, together with the reporters' introductions, the discussions and communications, the authors' replies and reports of the plenary sessions. The resultant volume contains nearly 1,000 pages. The papers cover such fields as stress distribution, the influence of temperature, frequency and environment; metallurgical aspects of fatigue; basic aspects of fatigue and engineering and industrial significance of fatigue. This last subject was subdivided into three sections concerned respectively with: general service, motor vehicles and specific components; airframes and aero engines; and marine engines, railways and welding.

Technical Reports of the Electrical Research Association, *Thorncroft Manor, Dorking Road, Leatherhead, Surrey.*

"The Relationship between Relative Humidity and the Moisture Content of Agricultural Products"—Preliminary Report, by P. Finn-Kelcey and D. G. Hulbert, W/T33 (24*s.*); "An All-Electric Multi-purpose Farm Drier. Design and Operation," by P. Finn-Kelcey and V. M. Owen, W/T34a. (2*s.*)

Physics: Vol. II—Electricity and Magnetism (30*s.*); **Vol. III—Light** (25*s.*). *Sir Isaac Pitman and Sons Limited, Pitman House, Parker Street, Kingsway, London, W.C.2.*

These two volumes and their companion first volume, which is entitled "Mechanics, Heat and Sound," are intended for students attending National Certificate courses in technical colleges. In each case, they cover the three-year course for the Ordinary National Certificate in applied physics, the more advanced work being produced in much less detail than the elementary work. This has been done deliberately in the belief that for first-year students with varying backgrounds, reading is necessary simply to make them at ease with the subject, whereas third-year students need a textbook rather for revision than for current learning. In the electricity volume, the treatment is in rationalised M.K.S. units.

How to Write Scientific and Technical Papers. By SAM F. TRELEASE. *Baillière, Tindall and Cox, Limited. 7 and 8 Henrietta Street, London, W.C.2.* (26*s.*)

This manual is intended to meet the practical needs of students and research workers who are preparing illustrated reports on scientific or technical subjects. It commences with the choosing of a research problem, using the library, and the first steps in treating data, referring briefly to the statistical approach to assessing the reliability of measurements. It then presents a detailed guide to writing a paper: the outline, the process of writing, subject matter and arrangement, presentation of ideas, revision, preparing and correcting a typewritten copy, estimating the length and giving brief details of type faces available. Then follows a discussion of good form and usage, punctuation, the use of capitals and italics, numbers, symbols, the Greek alphabet, citations, and so on. There follow sections on the preparation of tables, illustrations and proof reading. Although Dr. Trelease is attached to an American university, there is little in the book which is not equally applicable in this country.

Nickel and Its Alloys. By J. G. THOMPSON. U.S. National Bureau of Standards Circular No. 592. *U.S. Government Printing office, Washington 25, D.C.* (60 cents.)

The very great expansion which has taken place in the Canadian nickel industry in recent years and the development of new alloys to meet increasingly severe industrial conditions have prompted the publication of a fourth version of the U.S. Bureau of Standards' *Circular* on nickel, first issued in 1921 and last revised in 1950. The data given are comprehensive, and detailed information is furnished, in the Circular's 87 pages, on nickel ores and the chemical, physical and mechanical properties of the metal and of its ferrous and non-ferrous metal alloys.

Plastic Sheet Forming. By ROBERT L. BUTZKO. *The Reinhold Publishing Corporation, 430 Park Avenue, New York 22, N.Y.* (4·50 dol); and *Chapman and Hall Limited, 37 Essex Street, London, W.C.2.* (36*s.*)

The great advances made in recent years in the applications of plastics products produced by sheet-forming processes have prompted an increasing demand for information on this subject. The present book is intended as a guide and handy work of reference for those contemplating entering the sheet-forming industry and for those seeking to increase their knowledge of this new process. The work deals with materials, moulds and mould design, processes, and machines and costs.

TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Self-Gripping Spanner. F. C. DANIELLS AND CO. LTD., 11, Wardrobe Court, 146A Queen Victoria Street, London, E.C.4. Self-gripping ratchet spanner which slips round the nut after making a tightening stroke, to return for a fresh stroke. With or without knurled-nut adjustment, and in sizes from $\frac{3}{8}$ in to $1\frac{5}{8}$ in across the flats. Illustrated leaflet.

Universal Adhesive. CAULKING SERVICES LTD., 36 Great Queen Street, London, W.C.2. Pitabond binder for cement, concrete, bricks, plaster, asbestos, glass, metals, wood, plastics, slates, tiles, building blocks and building boards, fabrics, linoleum. Descriptive and instructive leaflet.

Adjustable Set Square. ANDERSON INSTRUMENT CO. LTD., 15 Lingfield Road, Wimbledon, S.W.19. Andy-Square, a conventional Armstrong scale developed into an adjustable set-square calibrated at 1° intervals 0 to 90°, with locking screw. Pocket instrument. Illustrated order form.

Handling

Handling Schemes. PATERSON HUGHES ENGINEERING COMPANY LIMITED, Bedford House, Bedford Street, London, W.C.2. Section 1 of catalogue contains general descriptions of handling systems, including belt, roller, and slat conveyors, screw, pallet and chain conveyors, travelling cranes, telphers and elevators.

Proportioning System. HENRY SIMON LIMITED, Cheadle Heath, Stockport. Select-o-Weigh automatic proportioning system for mixing materials accurately in batches. Hand or punched card control with automatic weight printing if desired. System is described with examples of use in an illustrated brochure.

Tongs and Pallets. WALTER SOMERS (MATERIALS HANDLING) LIMITED, Mucklow Hill, Hales Owen, near Birmingham. Automatic lifting tongs for steelworks handling of ingots and billets. Single and double types for loads up to 40 tons. Also tong and pallet combinations for handling stock. Illustrated brochures.

Conveyors and Feeders. THOS. W. WARD LIMITED, Albion Works, Sheffield. Conveyors for loose materials and for packages. Troughed and flat belts, chain or slat types and hoists. Also portable units and unit construction systems. General illustrated brochure.

Belt Materials. BTR INDUSTRIES LIMITED, Herga House, Vincent Square, London, S.W.1. Rubber and thermoplastic materials suitable for conveyor and elevator belts. Data including working stresses and capacities are given in a 52-page booklet together with examples in use.

Pneumatic Hoists and Rams. CONSOLIDATED PNEUMATIC TOOL COMPANY LIMITED, 232 Dawes Road, London, S.W.6. Pendant ram-type hoists with pistol grip controls for loads up to 38 cwt. Also bench, wall, and floor mounting rams with cylinders up to 9 in diameter. Brochure.

Mobile Cranes. STEELS ENGINEERING PRODUCTS LIMITED, Crown Works, Sunderland. Comprehensive catalogue of Coles mobile cranes for road and rail; including specifications of some 20 crane types and details of transmissions, cabs, chassis, jibs, brakes and the like.

Pan Conveyor. WHARTON ENGINEERS (ELSTREE) LIMITED, Watford Road, Elstree, Hertfordshire. The WS all-steel pan conveyor can be curved in both horizontal and vertical planes. Four standard sizes with capacities up to 337 tons per hour (struck) or 591 (heaped). Illustrated leaflet.

10 Ton Crane. RANSOMES AND RAPIER LIMITED, Waterside Works, Ipswich. Standard road-mounted mobile crane for 10 tons at 15 ft outreach. Diesel-electric or petrol-electric drive. Leaflet.

Conveyors. GEO. ROBSON AND COMPANY (CONVEYORS) LIMITED, Eclipse Engineering Works, Hodgson Street, Sheffield 3. Hoists, roller, slat and belt conveyors for a variety of materials. Brochure includes selection chart for conveyor type according to material to be handled.

Book Reviews

BETWEEN DESIGN OFFICE AND SITE

Prestressed Concrete: Theory and Practice. By P. B. MORICE and E. H. COOLEY. *Sir Isaac Pitman and Sons Limited, Pitman House, Parker Street, Kingsway, London, W.C.2.* (57*s.* 6*d.*)

Prestressed Concrete: Theory and Design. By R. H. EVANS and E. W. BENNETT. *Chapman and Hall Limited, 37 Essex Street, London, W.C.2.* (60*s.*)

With recent developments in prestressed concrete technique the publication of these two volumes is welcomed. Although neither of them present much new material or profound philosophy, they do put between covers data which heretofore have had to be collected from a number of sources. Morice and Cooley is described in the preface as " an attempt to collect together the more important aspects of structural analysis, design and current practical procedures." Evans and Bennett is similarly said to be written for the needs of " the student for university or professional examinations " and " the practising designer." The first succeeds in its more limited aims rather better than the second for, although the latter will appeal strongly to students, it is doubtful whether the designers' needs have been met. Inasmuch as designers' and students' requirements differ, the authors of the second have probably attempted too much in trying to satisfy both.

In comparing these volumes with some of the earlier published works, an absence of emphasis on some practical aspects is noticed (somewhat more in Evans and Bennett than in Morice and Cooley). While both books show that their authors are conscious of the difference between design and analysis, both fall short in varying degrees in their exposition of practical design aspects which are not a matter of calculation. As an example of the above, both treatments of " concordant " cables in continuous structures may be cited. Neither emphasises that in many practical designs the use of concordant cables is not only unnecessary or impracticable, but also consumes much more design time without any particular advantages.

Morice and Cooley provide chapters on theory, design, analysis and description of prestressing systems and a number of interesting works. A chapter on bridge-deck analysis dealing with transverse load distribution is a useful feature as is that dealing with tanks and pipes. The treatment of safety and ultimate load is good, though the distinction between " steel failure " and " concrete failure " and the undesirability of the latter is insufficiently emphasised. The data on concrete behaviour are concisely presented, but sources might have been quoted. The recommendation that post-tensioning should be applied only when the concrete strength has reached 6,000 lb per sq. in is somewhat conservative and may lead to the lengthening of construction time. The authors' view that a designer's choice between the Magnel and Freyssinet systems might depend on the fact that the minimum unit forces are 15 and 20 tons respectively is erroneous. Except for very small sections, this difference is of little practical significance in so far as it affects choice of systems. The text and illustrations are well presented, the authors' treatment of symbols is very good with no undue fussiness and the book is very readable.

Evans and Bennett deal with theory, design and analysis only and, therefore, have greater scope for a more detailed treatment of these aspects. A section on special applications dealing with a number of various structural forms is of great interest. Domes and shells are made the subject of a useful chapter, as also are liquid-retaining structures. Tables on section factors and prestress deflection factors are a welcome feature. The influence lines for end-block stresses are of great advantage. The choice of the term " load factor " as applicable to live load only is questionable. The ultimate-load treatment for over-reinforced beams is rather summary. A number of views expressed by the authors on practical design are controversial as, for example, their views on castellations in which the disadvantages are not mentioned. The use of smaller type and the notation recommended by the *First Report on Prestressed Concrete* of the Institution of Structural Engineers—an unhappy albeit logical choice—lessens the readability of a well-presented treatise.

Both books provide an index and bibliographies. Both incorporate matter open to criticism, for example, their underestimation of skilled trial and error in design, their presentation of the end-block treatment due to Magnel without criticism, their failure to point out that the " counter-shear " due to prestress is proportional to the cable inclination *from the line of the neutral axis*. Since, however, the present state of prestressed concrete technique makes some controversial views inevitable, such flaws do not detract too greatly from the overall value of the books.

ANCILLARY TO ENGINEERING

Engineering Economics, Book 1; Elements of Industrial Organisation. By T. H. BURNHAM and G. O. HOSKINS. Sixth Edition. *Sir Isaac Pitman and Sons Ltd., Pitman House, Parker Street, Kingsway, London, W.C.2.* (21*s.*)

An introduction to economics and industrial management for students requiring those subjects in the examinations of the engineering societies is provided by this standard text book, which has been thoroughly revised by the surviving author. Statistics have been brought up to date and a fair and balanced, if brief, chapter on the state in industry has been added at the end.

The field covered in the volume of just over 300 pages is enormous and it is not surprising that each subject, from the elements of economics to statistics and charts, is dealt with in bare outline. Whether the style is such as to encourage the student engineer to become interested in some of the subjects and to read further is doubtful; the mass of facts presented being not so much indigestible as lacking in attractiveness. If the object is not only to cram the student for an examination but also to start him on a course of reading to fit him for management, some of the bibliographies at the end of each chapter could with advantage be longer and more comprehensive; although they cannot be faulted on the ground of special viewpoint.

Not surprisingly, in such a concise text-book, very few words are wasted, the only exception being a chapter on research and development work which departs from the strictly factual style of the rest for a series of rather prosaic opinions.

No doubt this new edition, like its predecessors, will be found useful by graduate and student engineers as well as by those taking courses in management studies for the National Diploma at technical colleges. It would be interesting, however, to find out what impact its reading makes on the intellectual development and understanding of economics by young men under the age of 25, with little or no management experience and a strong technical bias. If the answer is very little, it may not be the fault of the authors but because the syllabus which the book is designed to meet has not been correctly designed for the purposes which its sponsors have in mind.

On the Shelf

By Frank H. Smith

Perishing Crust Department.—The body for which I work (sic) publishes a series of Data Sheets which, because they can be easily photo-copied (thus prejudicing sales) we do not send out on loan. A short while ago, I had a telephone request asking if they might be borrowed. I said that this could not be done and explained why not. I then asked who was speaking and was told that it was a government department, who, it seemed obvious, must subscribe to the Data Sheets. " Surely your library has a set " I said and the reply was " This *is* the Library. Oh yes, we have a set but we do not lend them out." This is known as information misership and Mr. Stephen Potter has not yet got round to it.

On page 57 (ENGRG., 25 July) I mentioned *Jet Propulsion's* bibliography on Artificial Satellites and implied that there was more to come. Part Two, covering the years 1957 and 1958, appears in the June number of that journal.

The June number of the *Journal of Applied Mechanics* (A.S.M.E.) contains abstracts of papers read at the third United States National Congress of Applied Mechanics, at Brown University, on 11 to 14 June. The full proceedings of the congress will be published in December. Copies, price 20 dol, may be obtained from the American Society of Mechanical Engineers, 29 West 39th Street, New York 18.

Progress, that excellent magazine of Unilever, has a little piece on the inside of its back cover about a new building for Thames Board Mills at Purfleet. The roof is a Silberkuhl type construction and is the first of its kind in the British Isles. With no supporting columns, it has a span of 120 ft, comprising a series of glazed steel arches and concrete shells. Any part of the arches can carry loads of up to ten tons. The curve of the roof throws water away from the building and no internal gutters or rain-water pipes are needed. A plastics insulation is used on the roof and this is considered to be better than either cork or insulation board. Also, it can be laid in all sorts of weather. The type of construction can be used for spans up to 210 ft. Silberkuhl, by the way, derives its name from its inventor, a German consulting engineer.

The Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank Crescent, Glasgow, C.2 (one of the longest-titled societies in the book) have sent me their *Year Book and List of Members* for 1958. There seems to be a fairly standard pattern for these year books nowadays. Usually, they comprise a review of the year's work, something about the library, something about the committees, a chunk from the council's report, and so on. Where they differ is in the attitude of the responsible body concerned. Some publish their year books themselves, some get them published elsewhere, and some include details in a number of their journal or proceedings, but the general fashion now is to hand over the whole thing, lock, stock and barrel, to a firm of publicity agents-cum-publishers. These people make the year book pay for itself by a combination of sales of advertising space and sales of the work itself. When this happens you come up against control of distribution. Some societies are fairly free with their handout, some are very free as long as you pay for it, and some will not let you have a copy unless you produce your passport, birth certificate and certificate of membership of the society. The reason for the last-mentioned attitude is, of course, to protect their members from begging letters, publishers' circulars and other activities. Actually, I have always thought it is one of those nose-cutting operations that spite faces. After all, one can always chuck unwanted mail in the fire (I, personally, enjoy everything that comes through the letter-box—even detergent coupons) but you may miss just the book you want because you fail to get a publisher's circular.

Design

LOW CONSUMPTION DIESEL ENGINE FOR HEAVY VEHICLES

With their new 150 h.p. 6 LX engine, Norris, Henty and Gardners Limited, Patricroft, Manchester, have entered the field of the larger vehicle and the rail car. Outstanding features are its low fuel consumption, smooth torque curve, quiet running and light weight.

The 6LX is a six cylinder four stroke engine of $4\frac{3}{4}$ in bore and 6 in stroke giving a swept volume of 638 cu. in or 10·45 litres. The maximum rated speed is 1,700 r.p.m. at which it develops 150 h.p. at sea level. Performance curves are shown in Fig. 2; it should be emphasised that these curves are average values obtained from standard production engines; the flat torque curve is particularly noticeable, reaching its maximum value of 485 lb-ft at about 1,000 r.p.m. This is undoubtedly a result of the great attention that has been paid to the design of the air passages; there are even deflectors in the inlet manifold as may be seen in Fig. 3. With a total weight, including flywheel, of approximately 1,583 lb a specific weight of 10·7 lb per h.p. has been achieved. A fuel consumption of 0·33 lb per b.h.p. hour is regularly obtained, representing a thermal efficiency of 39·75 per cent. The fuel consumption does not rise above 0·34 lb per b.h.p. hour over the speed range from 600 to 1,700 r.p.m., a notable achievement.

The main saving in weight has been by using an aluminium casting for the crankcase. A view of this (inverted) is shown in Fig. 4. Advantage has been taken of the lightness of the material to give a structure of great rigidity both longitudinally and transversely. The lower bearing caps (one of which is shown removed) are a light interference fit in the main casting and are held in place by through bolts which also hold the cylinder block. Cast bridge pieces spread the load. In addition there are two transverse bolts passing through each cap (except the rear end one) which virtually make the case into a complete box beam. This extreme rigidity has resulted in very quiet and smooth running. The seven main bearings in which the crankshaft runs have bronze shells with white metal linings. In accordance with previous Gardner practice a roller bearing at the front end acts as a steady for the timing gears, eliminating any shaft deflection at this point.

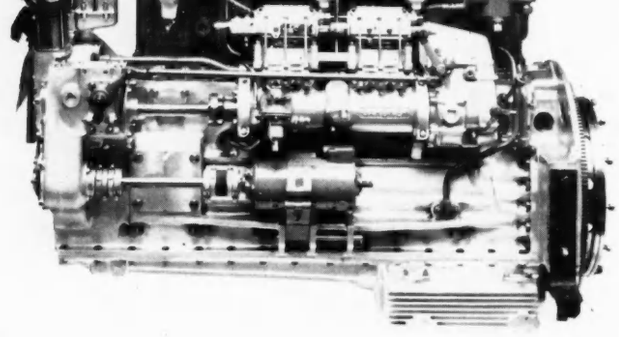
The crankshaft is a one-piece die stamping in heat-treated high tensile steel; it is machined all over. No local hardening of the pins or journals is carried out. Both pins and journals are—however—hollow, and to avoid any risk of sludge build up, oil from the journals to the pins is conveyed in pressed-in steel tubes. At the rear end of the shaft is a flange for bolting on the flywheel (which can vary according to the duty required) and at the front end is the sprocket for the timing and auxiliary drives and also a friction-type torsional vibration damper, which is mounted within the crankcase.

Like the crankshaft, the connecting rods are high tensile steel stampings, of H section and machined all over. The latter procedure reduces fatigue stresses due to surface irregularities and so improves the life of the rods. The big-end cap is held by two bolts, and the bearing is a thin steel wall shell lined with copper-lead and faced with copper tin. The little end has a bronze bush. Oil is conveyed from the big to the little end by a rifle drilling up the centre of the rod.

The pistons are cast in a medium silicon aluminium alloy to Gardner design; like the crankcase and other components they are a product of the firm's own foundry. They are round, tapering slightly to the crown, and have a hemispherical combustion chamber in the top. Their length provides a large bearing area. There are two pressure rings and one oil control ring. The gudgeon pin is set slightly off the piston axis and is a push fit in the piston when the latter is cold. It is retained by two aluminium end pads that bear against the cylinder walls.

The pistons run in dry liners pressed into the single high tensile cast iron cylinder block. As mentioned earlier, the block is held on the crankcase by through-bolts that also form the bearing cap studs. Like the crankcase the block is designed for rigidity and has ample space for the water flow round the cylinders. Small spigot tubes with rubber sealing rings pass the water to the heads so that the gasket is not called upon to make a water joint and the surfaces of the head and block are not subject to the risk of corrosion.

High tensile cast iron is also the material of the two cylinder heads. Studs bolt them to the block. The



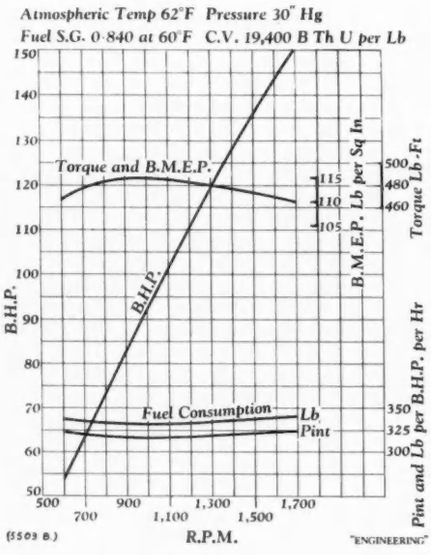
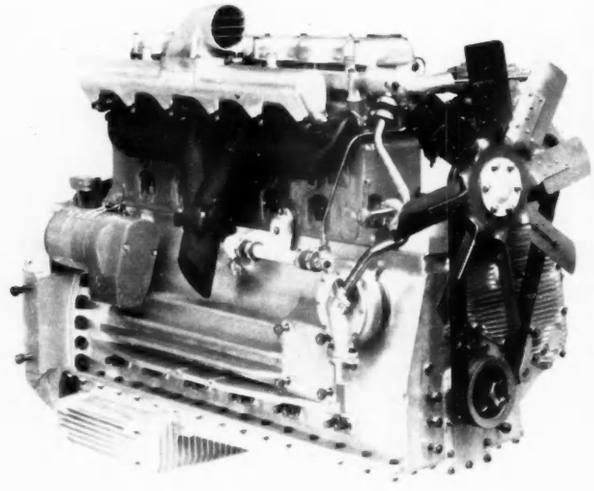


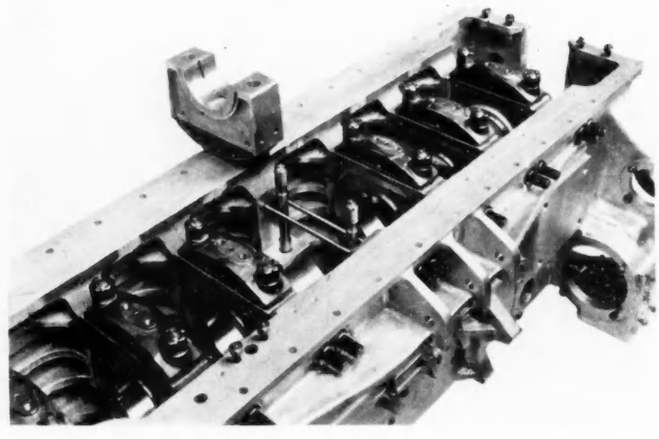
Fig. 1 (above) The 6LX engine is rated at 150 h.p. at 1,700 r.p.m. It is shown here fitted with a twin-cylinder exhauster.

Fig. 2 (left) Average performance curves show a minimum fuel consumption of 0·33 lb per b.h.p. hour and a commendably flat torque curve.

Fig. 3 (right) Guide vanes in the air intake have helped to produce the high performance.

Fig. 4 (below) The crankcase is an extremely stiff aluminium casting. Transverse bolts grip the bearing cap to make virtually a box section.





valve seats are formed by hard-alloy inserts which are pressed in, and the valves themselves are also made of wear resisting material. Lubrication is supplied through a comparatively large hole drilled through the valve levers and communicating with the hollow lever shaft. Flats are machined on the tops of the levers to form oil runways to the valves. This method has already been successfully employed on the earlier 6LW engine. By choosing the width of the flat, close control of the oil supply to the valves can be maintained. Excess oil merely flows off the edge of the flat and returns to the sump by way of the push-rod passages. The method avoids the use of very small oil holes that would be liable to block and stop the supply reaching the valves.

The inlet valve carries a mask or, more accurately, a deflector plate that guides the entering air and creates swirl within the cylinder. Decompression for setting the timing or for hand starting is obtained by lifting the inlet valves by a hand lever. Shallow polished aluminium covers fit on the heads to enclose the rocker gear and have synthetic rubber grommets to seal the entries of the fuel oil pipes. The junction of the cover and the head is above oil level so that an oil-tight joint is not required; there is metal-to-metal contact between the two.

As has been implied above, forced lubrication is employed throughout the engine. A gear pump driven from the camshaft through helical gears is mounted in the crankcase. All the oil is filtered before being fed to the distribution galleries. For those conditions when the engine is required to work at extreme angles, an additional pump can be fitted in the sump to feed the gear pump; for tropical conditions when an oil cooler is fitted there is provision for mounting a circulating gear pump on the fuel pump cam box, taking its drive from the fuel pump camshaft. The sump is in magnesium alloy and is available in several forms to suit particular applications.

The valve camshaft is chain driven from the crankshaft and is carried in seven white-metal bearings in the crankcase and one roller bearing in the timing cover. The inlet and exhaust cams are made in pairs and are fixed to the camshaft by set screws, enabling them to be removed for regrinding when necessary.

Fuel is supplied to the cylinders by six C.A.V. type BPF pumps mounted in blocks of three and driven from a common shaft connected through helical gears to the valve camshaft. Following earlier practice, one gear is free to slide on the helical splines on the shaft, a movement controlled by the accelerator and which varies the timing with engine speed. A variation of 8° is possible.

The six fuel injectors are of simple form with a two-diameter differential-area type valve. They are held in the cylinder head by a single stud and a clamping lever, the injector nozzle cap making a metal-to-metal joint with the head. For priming each pump is fitted with a hand lever.

Cooling water is circulated by a pump driven from the valve camshaft. This has a spherical carbon gland and a bronze impellor. Water is drawn from the bottom of the radiator and delivered to the cylinder block, the cylinder heads, and out through a thermostatic valve which can return the water direct to the pump intake or to the radiator according to the temperature. The radiator fan is belt driven.

Provision is made on the engine for the many accessories now met with on heavy vehicles. The model shown in Fig. 1 has a two-cylinder Gardner exhauster mounted on the front. A compressor can be mounted, also on the front, and driven by belts from the crankshaft pulley. Dynamos up to 8 in diameter can be accommodated and there is room for a hydraulic pump on the same shaft. A starter motor is normally fitted on the opposite side.

The overall and fixing dimensions of the 6LX are the same as those of the 110 h.p. 6LW, so operators can fix it in place of the less powerful engine without any modifications apart from enlarging intake and exhaust arrangements to suit the greater breathing requirements. The makers emphasise, however, that the 6LX is intended as an addition to their range and does not supersede any existing model. Any standard system of mounting can be employed, in addition to the Gardner three-point flexible arrangement.

MAIN-LINE DIESEL-ELECTRIC LOCOMOTIVE

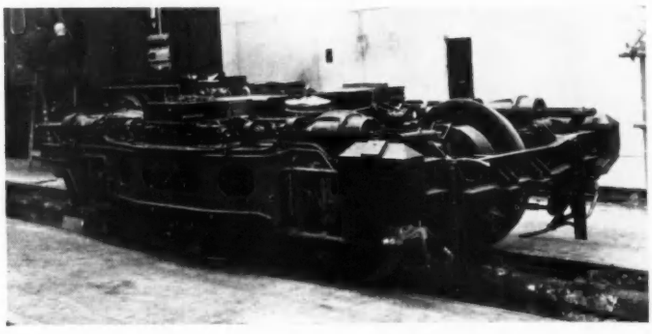
First Erected in British Railways Shops

The first main-line diesel-electric locomotive to be erected in British Railways workshops has recently been completed. Numbered D 5000, the locomotive is of 1,160 h.p., designed for mixed-traffic duties, and is capable of hauling passenger trains of up to 180 tons at 75 m.p.h., or of up to 450 tons at 60 m.p.h., on level track. It is the first to be completed of 30 of the same type being built at Derby Locomotive Works.

The locomotives have a driving cab at each end, can work singly or in multiple with other diesel-electric locomotives. With a maximum service speed of 75 m.p.h., they are classified as Type 2 in the British Railways classification of main-line diesel locomotives. They have a BB wheel arrangement (two four-wheeled bogies), and diesel-electric traction equipment supplied by British Thomson-Houston Company Limited, Rugby, incorporating six-cylinder Sulzer diesel Type 6LDA28 engines of 1,160 h.p., built at Vickers-Armstrongs' Works at Barrow-in-Furness for Sulzer Bros. (London) Limited. Aluminium alloys have been used for the driving cabs and for various doors, covers, etc. The bogies are of welded and riveted construction. The brakes are of the Oerlikon type made by Davies and Metcalfe Limited, and an anti-slip device of a design new to this country is fitted.

The principal dimensions of the locomotive are given below:

Length (over buffers)	50 ft 6 in
Height overall	12 ft 8 in
Width (over panels)	8 ft 10 in
Wheel diameter	3 ft. 9 in
Weight (in working order) ..	75 tons
Maximum tractive effort ..	40,000 lb
Fuel capacity	630 gallons.



D 5000, the first main-line diesel-electric locomotive erected in British Railways workshops. The bogies (right) are of welded and riveted construction.

An order for a further 84 of these B.T.H.-Sulzer diesel-electric traction equipments, for locomotives of the same design to be built in B.R. workshops, has since been announced by the British Transport Commission.

Eventually 20 of the locomotives will be allocated to the London Midland Region for hauling passenger and express freight trains between London and Crewe, but 15 of these are initially to be lent to the Southern Region, pending deliveries of the diesel-electric locomotives of 1,550 h.p. for the Kent Coast Electrification Scheme. From June, 1959, the locomotives will cover a wider range of duties hauling freight traffic and inter-regional passenger services which cannot be operated by electric locomotives or electric multiple-unit sets. The ten remaining locomotives are for use in the Eastern Region, based at Stratford, mainly on freight duties.

The locomotives, D 5000-D 5029, have been designed, and are being constructed, to the requirements of the British Transport Commission under the general direction of Mr. R. C. Bond and Mr. S. B. Warder (chief mechanical engineer and chief electrical engineer respectively of the British Railways Central Staff). The detailed design and supervision of construction are the responsibility of Mr. J. F. Harrison (chief mechanical and electrical engineer, Derby, London Midland Region).

Continuing **Design**

RE-DESIGNING VEHICLES TO SPEED MATERIALS HANDLING

Fig. 1 (above) The Tripad demountable body, showing the centre pallet being removed by fork-lift truck. One of the locating pyramids is clearly seen.

Fig. 2 (right) The B.R.S.-Douglas "Spotter" slave tractor for handling semi-trailers, showing automatic coupling.

THREE prototype vehicles being developed to facilitate handling bulk goods and to increase speed in transit have recently been demonstrated by British Road Services. Shown in the illustration above is the Tripad demountable body—in effect, three 5 ton pallets—fitted on a standard Leyland Octopus 24 ton rigid eight-wheeled chassis. The 24 ft platform body can be readily demounted in three 8 ft sections by a fork-lift truck. On remounting, the pallet is automatically aligned with the vehicle body by two locating "pyramids" on the latter which engage in mating recesses on the pallet. A locking device actuated by a detachable crank handle ensures that the pallet is firmly secured for transit. The demountable sections can be fitted with detachable headboards and sides to divide the load. They can also be assembled as containers.

The Tripad system has been devised by British Road Services to handle suitable flows of traffic more economically and the sections may readily be transferred to rail vehicles if required. With this method, vehicles can be loaded or unloaded in a matter of minutes since the sections can be handled without immobilising the carrying vehicle. Similarly, individual sections can be removed or mounted at intermediate points along a route. The system can be applied to a variety of vehicle types, including semi-trailers.

In the right-hand illustration is shown a "slave" tractor for use in depots for moving loaded and unloaded semi-trailers to and from loading banks and to parking places, etc. To accomplish this movement with ordinary service tractors means that the full coupling and uncoupling operation must be undertaken on each occasion, involving retraction and extension of the semi-trailer landing gear. This is a relatively slow process.

The new one-man operated "slave" motive-unit, based on the Douglas "Tugmaster," can be moved about the depot without the need for retracting the landing gear. It employs a hydraulically-elevated fifth wheel coupling capable of lifting the front of the semi-trailer so that the landing gear is clear of the ground.

The hydraulically-elevated fifth wheel is fitted with levelling "feelers" which, within the required limits, automatically actuate height-adjusting rams to permit smooth and positive engagement of the wheel with the rubbing plate of the semi-trailer. Preliminary trials with the prototypes have proved the success of the design. It is proposed to modify one of the prototypes experimentally so that the driver will be seated sideways, thus having an equally good view to the rear when coupling up, or forward when towing.

The third development, not illustrated, is a new parcels van with exceptional driving visibility and easy access to the cab. It has an integral body giving the minimum overall length for a given cubic capacity. The cab has sliding doors for safety and to make reversing easier, and provides a clear walk-through to enable the driver to use the pavement-side entrance.

TRANSISTORS FOR FLUORESCENT LIGHTING SUPPLY

The Vickers Vanguard airliner, now under construction for British European Airways and for Trans-Canada Airlines, will have fluorescent lighting supplied by a transistor-oscillator inverter unit operated from the aircraft's batteries at 22-28 V. The transistor inverter unit has been developed by the General Electric Company Limited, Magnet House, Kingsway, London, W.C.2, in conjunction with Vickers-Armstrongs (Aircraft) Limited, Weybridge, Surrey.

In the Vanguard, 4 ft and 3 ft Osram fluorescent tubes are being used for the main cabin lighting. To secure the desired low surface brightness from the Perspex diffusing enclosures, the tubes will be operated at a reduced wattage.

The advantages of this development in its application to aircraft cabin lighting lie partly in the low brightness of fluorescent tubes, and partly in the greater economy and reduced maintenance resulting from the use of the transistor-oscillator inverter. In the past, high-frequency rotary inverters have been costly and have usually required fairly frequent servicing when in constant use. They have also taken up space and added considerable weight.

The recent introduction of transistors of adequate power handling capacity has opened up an entirely new approach to the problem, owing to the inherent properties of the transistor—its small size and weight, the absence of moving or wearing parts, its indefinitely long life, mechanical robustness, and the high power-conversion efficiency obtainable.

For use in aircraft, a very important feature is the weight, and the G.E.C. transistor-inverter unit has been designed down to a weight of only 1½ lb. In view of the high ambient temperature in which the equipment must be capable of operating, this represents a significant achievement, because transistors are very critical in the temperature rise which they can withstand safely.

A G.E.C. transistor-inverter fluorescent lighting system is already being used experimentally in the "Caledonian" London-Glasgow express of the London Midland Region of British Railways. Seven first-class coaches of this train have been equipped with the system, operating on the 24 V supply from the coach batteries, which is converted by means of the inverter units to provide the requisite operating voltage at a high frequency. These sets use Osram 2 ft 20 W Warm White fluorescent tubes operated at full brightness. The experimental railway fitting consists of an anodised aluminium backplate serving as a reflector, on top of which is mounted a case containing the transistor-inverter and lamp circuit equipment. Dimensions of the case are approximately 12 in long by 3½ in wide by 2½ in high.

TRANSVERSE PROPULSION FOR "ORIANA"

At the request of the Orient Steam Navigation Company Limited, Vickers-Armstrongs (Shipbuilders) Limited have devised a system of transverse propulsion which will be installed in the new 40,000 ton liner Oriana, now being built at Barrow-in-Furness. The equipment will facilitate the manoeuvring of the vessel in confined waters, and by virtue of its instantaneous operation under direct control of the bridge, will greatly minimise the danger of damage to the vessel under these conditions.

The system consists of cylindrical steel casings arranged across and through the vessel at the bow and stern at an appropriate depth below the waterline. Within these casings are fitted the propeller assemblies. The propulsion units are based on the Vickers-Armstrongs Gill pump principle. Both the bow and stern installations consist of two units which may be operated singly or together, and all units are remotely controlled from control pedestals in the centre of the bridge and on either wing.

Metals and Materials

RECOVERY OF SULPHUR FROM COKE-OVEN GAS

New Appleby-Frodingham Process

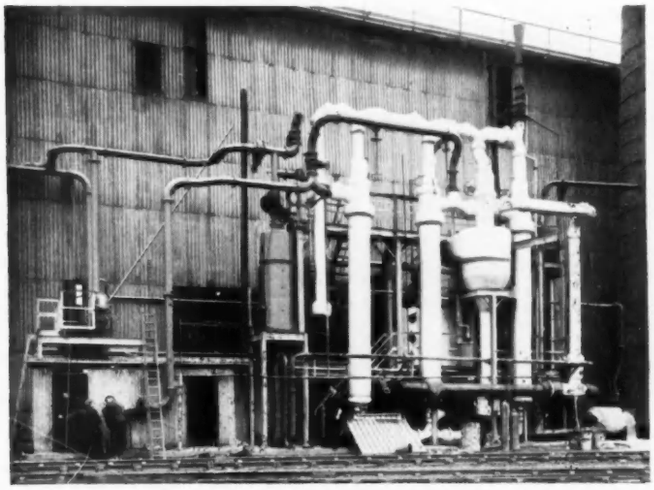
After ten years of experiments and pilot-plant trials, the Appleby-Frodingham Steel Company, a branch of the United Steel Companies Limited, Sheffield, have developed an entirely new combined de-sulphurising and sulphuric-acid plant which is claimed to be in advance of existing plant for similar processes. The first full-scale plant is now being installed at the Appleby-Frodingham works and is expected to be completed by mid-1959.

At most integrated steelworks, a certain proportion of coke-oven gas is used to fire the open-hearth melting furnaces, the remainder being used in reheating furnaces and soaking pits. This gas contains about 1 per cent of sulphur which, apart from adding to the difficulties of making low-sulphur steel, results in considerable quantities of sulphur dioxide being released into the atmosphere. In an integrated works making one million tons of steel ingots a year the use of the Frodingham de-sulphurising process enables the sulphur dioxide to be removed for the production of as much as 250 tons of sulphuric acid each week.

In the case of ordinary gasworks supplying town's gas, there is a statutory obligation to reduce the sulphur content of the gas to the equivalent of less than two parts per million by volume of sulphuretted hydrogen, a necessity which entails the provision of costly and extensive purification plant. Even after this is done, however, there remains a residue of organic sulphur which cannot be removed with existing purification equipment. It is this residual sulphur which causes corrosion in domestic hot water and similar appliances.

The plant developed by Appleby-Frodingham consists essentially of a fluidised hot iron oxide absorber and regenerator. It is capable of removing both hydrogen sulphide and organic sulphur and reducing the sulphur content of the gas to very low levels; at the same time, considerable quantities of sulphuric acid are recovered. Once the process has been started, the heat generated by the combustion of the absorbed sulphur makes the process self-sustaining.

Because the process employs hot gas, it is very much faster than the conventional iron oxide boxes of purification towers, and the use of fluidised beds reduces the amount of spent oxide by four-fifths, simplifying its handling and distribution. In compactness and capital cost the process compares very favourably with existing methods, while the entire operation of the full-scale plant requires only two men per shift.



Pilot plant for de-sulphurising coke-oven gas by the Appleby-Frodingham process which has been in operation for two years, purifying up to 3 million cu. ft of gas per day.

A pilot plant, shown in the accompanying illustration, has been in successful operation for two years, purifying up to 3 million cu. ft of coke-oven gas a day. The full-scale plant, when completed, will deal with 32 million cu. ft of gas a day.

The new Frodingham de-sulphurisation process is also likely to be of interest to the gas, chemical, and petroleum industries, especially as under the provisions of the Clean Air Act, the discharging of sulphur dioxide to atmosphere may be subject to regulation.

Appleby-Frodingham have appointed two licensees to build plants based on this process. They are Henry Balfour and Company Limited, of Leven, Fife, and W. J. Fraser and Company Limited, of Romford, Essex. The latter company are at present constructing the full-scale plant at the Appleby-Frodingham works.

REDUCING WORM HOLES IN WELDED PIPE JOINTS

"Piping" (also known as "worm-holes") is a common fault in pipe butt welding, especially by the upwards method. The simplest and most direct definition of piping is that given in B.S.499:1952 "Glossary of Terms relating to Weld Imperfections." There a pipe or worm-hole is defined as "an elongated or tubular cavity due to entrapped gas." Fig. 1 shows examples of such cavities. They frequently occur in the root run of a pipe joint, particularly when a heavy weld is deposited and when the penetration bead is rather large. Thus it is most likely to occur in areas of excess penetration, that is, between the 9 o'clock and 12 o'clock positions in a pipe joint.

Recent research in the laboratories of Quasi-Arc Company Limited and reports from some of the firm's customers have shown that piping can be considerably reduced by the use of a wider root gap. This may seem rather contradictory, since a wider gap would seem to indicate a larger root run, but, in fact, if the gap is sufficiently wide it is possible to reduce the amount of heat right in the centre of the pool where piping usually occurs. Fig. 2 shows the improvement that can be realised. It is achieved by using a weaving technique with a slight pause at the edges and a rapid flick across the centre of the pool which keeps the weld bead as thin as possible. The work carried out has shown that the gap should certainly not be less than $\frac{1}{8}$ in and should preferably be of the order of $\frac{5}{32}$ in with a $\frac{1}{16}$ in root face. This applies to all thicknesses and diameters of pipe, but does not apply where the pipe is welded by the "stove-pipe" or vertical downwards method. It is advisable to use as small an electrode as possible, preferably a 12 s.w.g. but certainly not more than a 10 s.w.g. for all root runs in pipes welded by the upwards method.

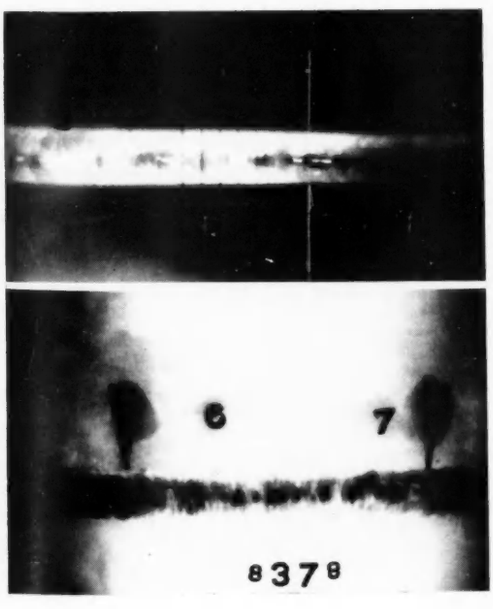


Fig. 1 (top) The radiograph of a pipe joint welded with a $\frac{1}{16}$ in root gap reveals the presence of "piping."

Fig. 2 (below) A similar joint, welded using a larger $\frac{5}{32}$ in root gap, shows a marked improvement in the weld quality.

MORE M.P.G.—BY CASTOR OIL

Following experiments by their research department, mention of which was made in ENGINEERING for 23 May (page 644), London Transport are to start large-scale tests using castor oil for rear-axle lubrication. The tests involve one-fifth of all London's buses—about 1,358 double deckers running in all areas—and are expected to yield an immediate saving of £20,000 a year in fuel costs.

Castor oil has been used to some extent as a motor vehicle lubricant for many years, for instance in racing cars and even in buses, but latterly it has been largely replaced by mineral oil, because of its higher cost and tendency to gumming. It has also been used at times for rear-axle lubrication, but the fuel-saving potentialities were not generally appreciated until careful and accurate measurements were made, including compensations for traffic and stopping variations, temperature and other factors. The higher cost of castor oil will be insignificant in comparison with the miles-per-gallon gain as only a small quantity is used in rear axles, while the tendency to gumming has been overcome by introducing an oxidation inhibitor. It may seem surprising to include temperature among the factors to be compensated, but a drop of 1° F in the mean annual figure represents an increase of about £20,000 in the fuel bill. An unscheduled stop due to traffic conditions costs 0·8*d* as against 0·6*d* for a routine one, on account of the greater acceleration subsequently required to maintain schedule.

The gain will be supplementary to one of

Continuing Metals and Materials

£350,000 a year, which London Transport has already made through previous bus lubrication research, brought about by a changeover to much thinner oil (SAE10W) for engine lubrication than that hitherto generally regarded as standard for buses. This produced a fuel oil saving of 6 per cent in London's buses. The use of the thinner lubricant has since become general among bus operators.

Before reaching the present stage with rear-axle lubrication, London Transport experimented with several oils of different viscosities to see if thinner oils would produce a saving in fuel as they had done in the case of the engine lubricants. Various grades of oil down to SAE5 were used instead of the normal SAE140 rear-axle type, but it was found that within this range there was no detectable effect on fuel consumption.

Tests were made with certain proprietary blends of castor oil and a wholly synthetic oil. An improvement of 2 to 3 per cent was noted in the m.p.g. obtained with these blends; a similar improvement was obtained when castor oil and a synthetic oil were each tested separately. It was concluded, therefore, that the benefit was due to the improved lubricity of these oils which resulted in a reduction in friction losses. While the large-scale test on 1,358 buses is being made with castor oil, tests are also being made at one garage with a synthetic oil, the long-term performance of which has still to be determined.

The research in connection with the rear-axle lubrication has been carried out under the general direction of the Director of Research, Mr. A. T. Wilford, A.R.C.S., B.Sc., F.R.I.C., F.S.S., C.I.Mech.E., F.Inst.Pet., while the large-scale tests are being carried out by the Department of the Chief Mechanical Engineer, Road Services, Mr. A. A. M. Durrant, C.B.E.

SYMPOSIUM ON RUBBER

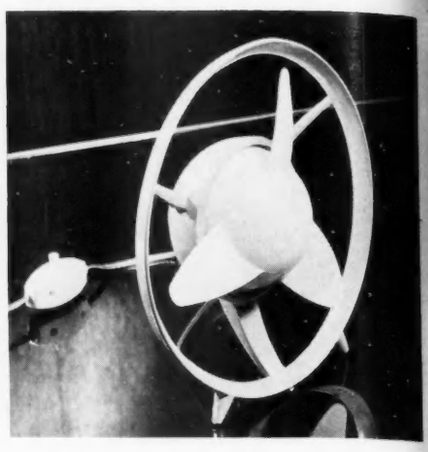
Much progress has been made during recent years in the study of a wide variety of rubbers and their characteristics. To a large extent, the employment of rubber in engineering is a relatively modern innovation but, even so, many uses for this material have already been found, such as for bearing pads in bridges, suspension for vehicles and rolling stock, and as a foundation for machine tools.

With a view to bringing these and similar developments to the attention of engineers interested in the engineering applications of rubber, arrangements have been made by the Research Association of British Rubber Manufacturers to hold a three-day symposium at the Shropshire Adult College, Attingham Park, Atcham, near Shrewsbury. The theme chosen is "Dynamic Design with Rubber."

Those attending the conference will assemble at the college for dinner on 7 October next, and the meetings will extend over the three days following, until 10 October. Morning and afternoon sessions for the reading and discussion of papers will take place on 8 and 9 October. The morning of the last day will be spent at the Association's laboratories at Shawbury, where there will be demonstrations of apparatus and methods used for studying the dynamic properties of rubbers. Applications to attend should be addressed to the secretary of the Association, Shawbury, Shrewsbury, Shropshire, as much in advance of the opening date as possible. The fee will be 10 guineas to members of RABRM, and 12 guineas for others.

Engineering at Home

RESILIENT FAN



A 7 in diameter table fan, known as the Two-Tone, is being produced by the General Electric Company Limited, Kingsway, London, W.C.2. It is moulded in polythene and has sufficient resilience to withstand being knocked off the table. The company also claim that the fan's moulded impellers are so shaped that they present a "solid wall" when running, through which it is impossible to poke a finger. An induction motor, which does not interfere with radio or television reception, is used to drive the blades. The clean lines and general appearance of this article are shown in the attached illustration. The fan will operate for about 36 hours on one unit of electricity. It is available in two voltage ranges only: 200-230 V and 230-250 V. Three colour combinations are offered and the price is 73*s*.

SOUTHAMPTON INTERVIEW STUDIO

The BBC television studio in South Western House, Southampton, enables local interviews to be broadcast either from the national television network or from the transmitter at Rowridge, Isle of Wight, only. All the vision and sound equipment is installed in the studio, which measures 20 ft by 18 ft. There is no separate control room.

The compact arrangement is aided by the use of a Marconi Vidicon camera in which the camera control unit is integral with the camera, and by the use of a transistorised synchronising-pulse generator measuring only 5 in by 7 in by 9¼ in. The camera uses printed circuitry throughout and includes a small waveform monitor in addition to the electronic viewfinder. The installation has been designed so that it is possible to leave the camera, lighting, and sound equipment ready to be switched on by a commentator when no engineer is on duty. A 21 in Dynatron console receiver serves as a radio check and as a picture monitor for cueing.

Picture and sound signals from the BBC Southampton studio are relayed to the Rowridge site by a microwave transmitter installed on the roof of the building and working in the 4,600 Mc/s band. At Rowridge the signals when received can be switched either for local transmission from the station or to London, over a Post Office link, for distribution over the whole BBC network. The changeover switching operation at Rowridge can be carried out remotely from the BBC television switching centre in London.

RADIANT HEATER

A radiant heater operating from paraffin is produced by Sterling Incandescent Company Limited, Dagenham, Essex. It has an output of about 9,000 B.t.u. at the maximum fuel consumption rate of one gallon in 16 hours. The tank capacity is one gallon, which will last 28 hours at minimum output. The unit stands 20·5 in high.

CHILLERTON DOWN

Full-power test transmissions from the Independent Television Authority's new station at Chillerton Down, Isle of Wight, began on 1 August. They are to be transmitted from 10 a.m. to 10 p.m. on Mondays to Saturdays until the formal opening of the station on 30 August.

It is the seventh transmitting station to be built by the ITA and will serve some 2¾ million people living in the area stretching from Weymouth to Newbury and Brighton. The programmes transmitted from Chillerton Down will be provided by Southern Television who have offices and studios in Southampton. With the opening of this station over 80 per cent of the population of the United Kingdom will have been brought within reach of an alternative television service.

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